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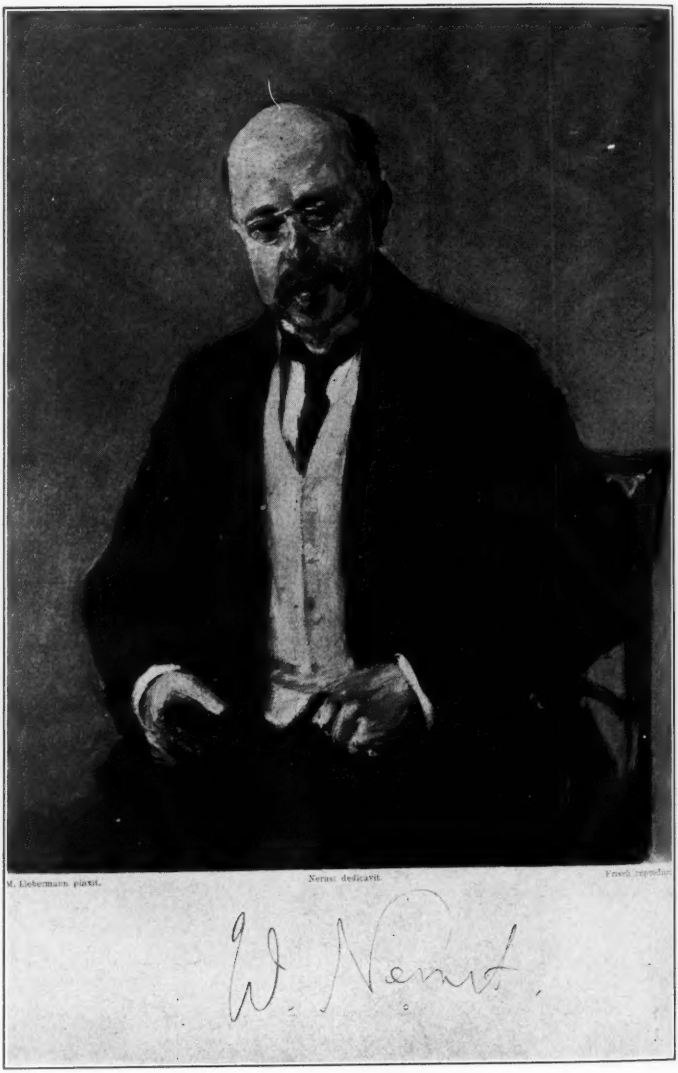

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EDITOR'S OUTLOOK

STUDENTS of thermodynamics at the Physikalische Institut of the University of Berlin are still privileged to receive their elementary training from Walther Nernst, whose contributions to this field of physical chemistry have been so notable that for this phase of his scientific activities he received the Nobel award in chemistry for 1920. The short, stout figure of the Director of the Institut, showing at sixty-six in voice and manner the encroachment of age, is familiar in laboratory, lecture hall, and colloquium at the University. His traditional introduction to his lectures, which has established his place in the minds of succeeding classes of the students whom he has inspired and directed, may serve to orient him here: "the first law of thermodynamics," he says, "rests on the shoulders of many; the second law, on the shoulders of a few; the third, on the shoulders of one—mine!" The third law of thermodynamics, which makes possible the calculation of chemical affinity and chemical equilibria from thermal data, has been developed at Berlin by Nernst and his associates through their study of specific heats at low temperature and has been subjected to extensive experimental tests. These tests have been strikingly confirmatory; well-known individual instances concern the dissociation of water vapor and of nitric oxide, and the affinity of carbon for oxygen.

Walther Nernst, 1864–

The work of Nernst in thermochemistry has been carried out principally at Berlin, where he first came in 1905 to succeed Landolt as ordinary professor of physics in the University. In 1922 he became director of the Physikalische Technische Reichsanstalt at Charlottenburg, but he resigned in 1925 to assume his present duties as director of the Physikalische Institut of the University of Berlin.

Nernst, a native of Briesen, West Prussia, where he was born on June 25, 1864, attended the humanistic gymnasium of that town. He took his university training at Zürich, Berlin, Graz, and Würzburg, receiving his doctorate from the last-named university in 1887. His dissertation was in physics, for chemistry and mathematics which have so largely figured in his professional life had but second place in his student interests. He had the good fortune to spend the succeeding two years as assistant to Ostwald in the physico-chemical institute of the University of Leipzig, at the period when physical chemistry, in the hands of Ostwald, Arrhenius, and van't Hoff, was becoming an independent and important branch of the science. At Leipzig Nernst qualified himself for university teaching, and went to Göttingen as an assistant in 1890. Passing through various professional gradations to a professorship, he remained at Göttingen, in spite of calls to Giessen, Munich, and Berlin, until in 1905 an offer from Berlin finally brought him to the city which has since been the scene of his labors as a teacher and investigator.

In addition to his work in thermochemistry, Nernst has made valuable

additions to the knowledge of the primary cell through his work on the solution-tensions of metals. Important, also, have been his studies on the nature of saturated solutions in connection with the diffusion, hydration, and dissociation of electrolytes, from which was evolved the general theory of the generation of electrolytic currents. He is also known for the invention of the electric glow lamp that bears his name which, although it has given place in general use to the metal filament lamp, was at the time of its invention a distinct advance on the carbon lamp and is still used in scientific work as a concentrated source of light.

Nernst has assembled the results of his work in thermodynamics in his texts, "Experimental and Theoretical Applications of Thermodynamics to Chemistry" and "The New Heat Theorem," and has further contributed to the literature of the science through his services as editor of the *Jahrbuch der Elektrochemie*, the *Zeitschrift für angewandte Chemie*, and the *Zeitschrift für Elektrochemie*.

Nernst is still active in research. His investigations in thermochemistry continue and he has recently, in association with his assistant, M. Czerny, developed a satisfactory method of recording infra-red radiation photographically. He is never to be missed from the weekly physics colloquium of the University, and the light that often burns late in the evenings in his laboratory may be taken as a symbol of the spirit that still hopes to build in the future on the accomplishments of the past.

The JOURNAL OF CHEMICAL EDUCATION *gratefully acknowledges the courtesy of Dr. K. Freudenberg, of the University of Heidelberg, for the accompanying portrait of Professor Nernst, and of Dr. R. E. Oesper, of the University of Cincinnati, Dr. L. H. Reyerson, of the University of Minnesota, and Mr. Ralph Witt, of The Johns Hopkins University, for material on which this biographical sketch is based.*

Interest

THERE was once a Sunday-school teacher who taught a class of small, restless, and none-too-tractable boys. Her class was always a model of order and her pupils listened with rapt attention. Investigation of this phenomenon revealed that she told them fairy stories.

Some of the lecture-demonstration experiments which are recommended to us as excellent for arousing interest and fixing attention remind us of that Sunday-school teacher and her methods.

The pagan traditions are perhaps as admirable in their way as the Christian, but is their proper place in the Sunday school? The vaudeville act is probably a harmless and amusing entertainment, but is its proper place in the lecture room?

GLASS, ITS COMPOSITION AND PROPERTIES

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The following paper gives a general survey of the composition and properties of glass, and a discussion of the factors which determine glass composition. The greater proportion of the glasses of commerce are essentially soda-lime-silica glasses, of a composition in or near the stability field of the compound $Na_2O{\cdot}3CaO{\cdot}6SiO_2$. *This compound is characterized by an inherent reluctance to crystallize, and its field is one of low temperature and high viscosity. These are dominant factors in making possible the manufacture of glass, causing it to be above its freezing point at the temperature at which it is manufactured and worked; and at its freezing point to be too viscous to crystallize. Many types of glass have been derived from this original glass composition, by multiplying the number of components; but the general requirement of low freezing point and high viscosity at the freezing point is fulfilled in all satisfactory glass compositions.*

. . . . . .

Ancient and Medieval Glassware

Man's use of glass goes back to a period prior not only to history but also to archaeology. The oldest piece of glass bearing an authenticated date is a large ball-bead with the cartouche of Amenhotep (1551–1527 B.C.) now in the Ashmolean Museum at Oxford, but pieces exist which can be attributed with fair accuracy to the First Dynasty of Egypt, that is, about 5500 B.C. Glass beads are plentiful in the excavations of a cemetery of the Third Dynasty of Ur (2450 B.C.). It is probable that about 1500 B.C. Syrian workers were brought into Egypt to establish glass manufacture, from which were descended the long-famous glass houses of Alexandria. From Egypt the industry was carried to Rome at about the beginning of the Christian Era, from which place the cult spread to Constantinople and Venice, both famous centers of glass manufacture. Throughout the middle ages the use of glass was essentially confined to objects of art, and not until the close of the third century was it used for glazing. The magnificent medieval stained glass windows of York Minster were early attempts at glass making, inferior to modern glassware in composition and in freedom from technical defects. Much of the beauty of these ancient windows comes from the inferior quality of the glass, softened and mellowed by the corrosive action of atmospheric agencies on glassware of composition ill-adapted for such exposed service. The superiority of modern glassware is so marked that glass of the composition of the best of that found in Egyptian tombs would today be rejected by any discriminating user because of its inferior behavior when exposed to the usual tests for weathering ability. The earlier glass makers, indeed, almost up to the present century, were not free to vary the nature and pro-

portions of their ingredients, but rather they were confined to the narrowest empiricism by the secret formulas on which their craft was founded, and outside of which they had neither knowledge nor daring enough to venture. The first of whom we have record to approach the glass problem with an experimental spirit was that ubiquitous pioneer Faraday, but the trail he blazed remained untrodden for sixty years, until Schott began those studies which resulted in the commercial production of numerous new types of glass, with properties carefully chosen for the purpose in hand and obtained by intelligent adjustment of the chemical composition. For generations glass consisted essentially of the three ingredients, soda (Na_2O), lime (CaO), and silica (SiO_2), together with the numerous but adventitious impurities introduced from crude raw materials selected and bought on tradition alone. The glassmaker today makes his choice from the whole array of chemical elements, and inclusion of a given material is determined, not by tradition, but by the properties which it will impart to the glass.

Modern glassware is made up of many different types, types differing in their appearance, properties, uses, and compositions; but of all these types those which are essentially mixtures of soda, lime, and silica make up an overwhelmingly preponderant proportion of the total production. Moreover, not only is most glassware largely composed of these three oxides but their relative proportions always remain the same, within rather narrow limits. Not only is this true of modern glassware, but it has been true of glassware from the earliest days. This is shown by the numerous analyses by Neumann (*1*), a few of which are shown in Table 1. There is a good

TABLE I

Analyses of Ancient and Medieval Glassware

	1	*2*	*3*	*4*	*5*	*6*
SiO_2.....	67.82	63.86	65.95	68.45	67.74	66.35
$CaO + MgO$.....	6.33	12.04	8.26	11.10	7.66	7.77
$Na_2O + K_2O$.....	16.05	23.46	21.26	15.00	21.70	22.12
$Al_2O_3 + Fe_2O_3$....	5.44	1.32	2.77	4.74	4.48	3.25

1. Dark blue glass from broken vessels from the Tombs at Thebes, 1500 B.C.
2. Transparent glass, Tel et Amara, 1400 B.C.
3. Colorless Egyptian glass, Island of Elephantine, 200–100 B.C.
4. Deep dark blue Alexandrian glass, Egyptian late period.
5. Roman glass, Mainz, 2nd Century A.D.
6. Roman glass, Cologne, greenish yellow. Fifth century.

reason for the circumstance that the common run of glassware today has about the same composition it has always had; and an inquiry into this reason will lead to a better understanding not only of this particular glass but also of the glass-making problem as a whole.

Nature of Glass

It is a matter of scientific commonplace that those compositions of matter known as glasses differ from the majority of materials in that they pass from the thin molten condition obtaining during their manufacture, through a continuously changing sequence, to a hard, brittle substance of sufficient strength and rigidity to be of inestimable service to mankind; instead of undergoing at some stage in the cooling process a discontinuous change in properties such as that which occurs when a metal, a molten salt, or water freezes. Many chemists who have constructed apparatus by the usual glass-blowing process have observed that most glasses, when manipulated too long within certain temperature ranges, will undergo a similar discontinuous change which, once started, generally goes from bad to worse. The process is known as devitrification, and glasses differ greatly in their tendency toward devitrification. Some soft glass will stand but little working before the blowpipe; glasses of the resistance type are greatly superior; and glasses of the Pyrex type are quite free from devitrification troubles. The major factor in limiting the compositions which may be employed in glass-manufacturing practice is this tendency toward devitrification, for if the material cannot be fashioned into shape, annealed and cooled without devitrification it is no longer glass, and its usefulness has vanished.

In considering the problem of the devitrification of glass, the most competent datum is the devitrification temperature. When equilibrium relationships only are considered, leaving out of account all questions of velocity of reaction, glass differs in no way from any other complex solution, either of molten salts or of salts in water. Each of these has a definite freezing or melting point; a definite temperature of equilibrium between the first trace of crystals to freeze on cooling, or the last trace of crystals to dissolve on heating; and glasses differ from other compositions of matter only in the ease with which the material passes through its freezing point into an undercooled condition, and in the practical permanence of this undercooled condition.

Methods of Studying Phase Relations in Glass

The methods of studying the phase relations in glasses must differ from those commonly used. With salts and metals, the phase transformations may be followed by means of heating or cooling curves. When such materials are heated at a uniform rate, an absorption of heat takes place when melting begins, which is indicated by the temperature of the charge falling behind that of the furnace, or even remaining constant. Because of the slowness of the melting process in devitrified glasses, as well as in many other silicate melts, no indication of the beginning of melting can be found

on the heating curve; and, indeed, the material may even be superheated many degrees above the temperature of melting without much formation of liquid. This condition is, of course, unstable and, if held above the requisite temperature, the crystals will dissolve, but overheating is the common occurrence. Similarly, on cooling the glass does not freeze—that is why it remains a glass—and hence the type of discontinuity which gives so marked an effect in the freezing of a metal cannot be observed. If held a long enough time, however, crystals will separate. Accordingly the "quenching" method is used in studying such mixtures. A few milligrams of the material, wrapped in thin platinum or gold foil, are held at a known constant temperature for a long enough time for equilibrium to be reached, which may be a matter of hours, days, or even weeks. Then the charge is cooled in such a manner as to freeze the equilibrium, and examined with the petrographic microscope. If all glass, the temperature of heat treatment was above the liquidus; if a mixture of glass and crystals, it was below the liquidus; and by measuring the properties of the crystals they can be positively identified. With difficult mixtures it is customary to have two charges side by side, one initially glass, the other previously crystallized. The heating must be continued long enough for both charges to attain the same condition.

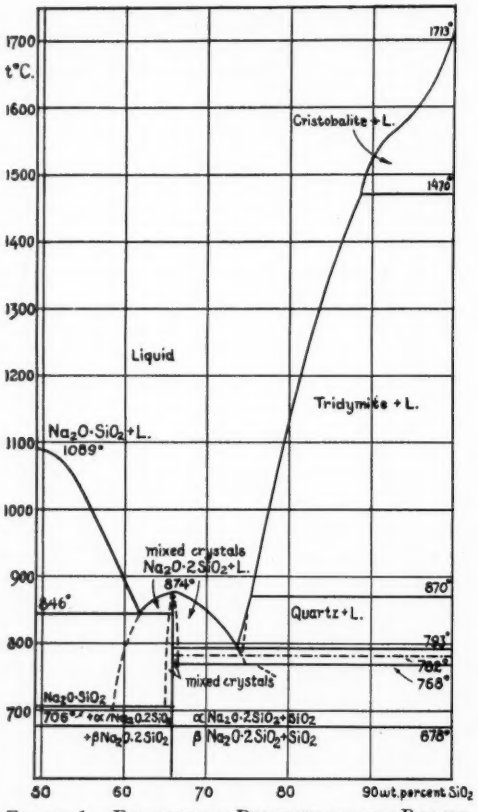


FIGURE 1.—EQUILIBRIUM DIAGRAM FOR THE BINARY SYSTEM $Na_2O \cdot SiO_2$–SiO_2

To illustrate the application of the method the system $Na_2O \cdot SiO_2$–SiO_2 (*2*) will be considered. This is a two-component system, at constant pres-

sure, hence two phases can coexist over a range of temperature, while coexistence of three phases, one liquid and two crystalline, renders the system invariant, and the temperature and liquid composition are fixed. The details are shown in Figure 1, in which temperature is represented along the vertical axis, while the argument along the horizontal axis is the weight per cent SiO_2 in the mixture. Pure sodium metasilicate, $Na_2O \cdot SiO_2$, melts at 1089°, and it can be studied either by the quenching or the heating curve method. It crystallizes so readily that large melts cannot be cooled as glass, but always crystallize. On the other hand, it undercools to such an extent that melting-point determinations by the cooling curve method are not reliable. Another compound found in this system is sodium disilicate, $Na_2O \cdot 2SiO_2$.* It melts at 874°, and the quenching method is the only satisfactory method for determining its melting point. Sodium disilicate is noteworthy not only for its low melting point, but also for the flatness of the maximum on the melting-point curve. A flat melting-point curve is indicative of dissociation in the liquid phase; since the compound is largely dissociated, addition of either silica or soda introduces no new molecular species, but merely shifts the equilibrium between those present. Addition of SiO_2 to $Na_2O \cdot SiO_2$ lowers its melting point, as indicated by the curve in Figure 1, and similarly addition of Na_2O to $Na_2O \cdot 2SiO_2$ lowers its melting point. The two curves intersect at 846°, and at this point of intersection, or eutectic, three phases can coexist, $Na_2O \cdot SiO_2$, $Na_2O \cdot 2SiO_2$ and a liquid containing 62.1% SiO_2. This is an invariant point, and both temperature and liquid composition are fixed. When SiO_2 is added to $Na_2O \cdot 2SiO_2$ the melting point is likewise lowered, until at 793° and 73.9 per cent SiO_2 the $Na_2O \cdot 2SiO_2$–quartz eutectic is reached. On further increase in the SiO_2 content the melting point is raised, and one of the forms of crystalline silica remains solid phase; first quartz, up to 870°, then tridymite, from 870 to 1470°, then cristobalite, up to the melting point at 1710°.

The low temperature of this eutectic is of great importance in both glass making and geology. Here is observed a remarkable melting-point lowering. The melting point of cristobalite, the stable high-temperature form of crystalline silica, is 1710°; this eutectic is at 793°; a lowering of almost 1000° on the addition of 25 per cent of sodium oxide. This eutectic would make an excellent glass were it not for the fact that it is easily attacked by water, and hence is not stable in the air. It is of course essen-

* It will be noted that throughout this paper the compositions of compounds are indicated by means of the proportions of the component oxides. This is not to be taken as assuming that definite experimental evidence relative to the structure of these compounds is best represented by such formulas, but rather that such formulas indicate our ignorance. There might be some justification for writing the above compounds as Na_2SiO_3 and $Na_2Si_2O_5$, and assuming them to be salts of metasilicic and disilicic acids, but how should the compound $Na_2O \cdot 3CaO \cdot 6SiO_2$, to be discussed later, be regarded?

tial that glasses be stable not only on exposure to the air, but also under far more drastic treatment, and for this reason the presence of other oxides is necessary. The greater part of the "water glass" of commerce is near to the composition of this eutectic, and devitrification troubles are unknown in that industry. In the manufacture of water glass the anhydrous glass is first prepared by melting a mixture of sand and sodium carbonate, then dissolved in water, and the solution so prepared has many industrial applications. Most glasses are stabilized by the addition

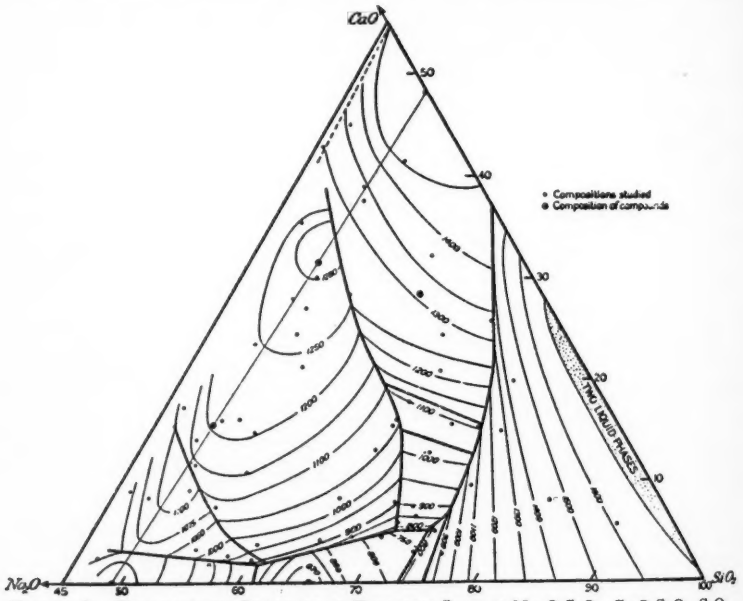


FIGURE 2.—EQUILIBRIUM DIAGRAM OF TERNARY SYSTEM $Na_2O{\cdot}SiO_2$–$CaO{\cdot}SiO_2$–SiO_2, SHOWING ISOTHERMS

of CaO, and the melting relations in the ternary system Na_2O–CaO–SiO_2 (*3*) will next be considered.

The crystallization relationships in that portion of the ternary system included within the boundaries $Na_2O{\cdot}SiO_2$–$CaO{\cdot}SiO_2$–SiO_2 are shown in Figures 2, 3, and 4. Figures 2 and 3 are parts of the larger equilateral triangle whose vertices represent pure Na_2O, CaO, and SiO_2. In such an equilateral triangle, the position of a point representing a desired composition is given by the center of gravity of the triangle when loaded at each corner with the proportional quantities of that component. A point on a side represents a mixture containing only two components, the one represented by the opposite apex being absent; the points on a line through

any apex represent mixtures in which the ratio of the two other components remains constant; and the points on a line parallel to a side represent mixtures in which the percentage of the component represented by the apex opposite to that side is constant. For example, points on the side Na_2O–SiO_2 represent the same binary mixtures shown in Figure 1; points on a line through SiO_2 and the compound $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ represent mixtures in which the Na_2O:CaO ratio is 1:2; and all mixtures lying on a line parallel to the Na_2O–SiO_2 side have the same CaO content. In the figure the scale is indicated on the sides, and may be transferred

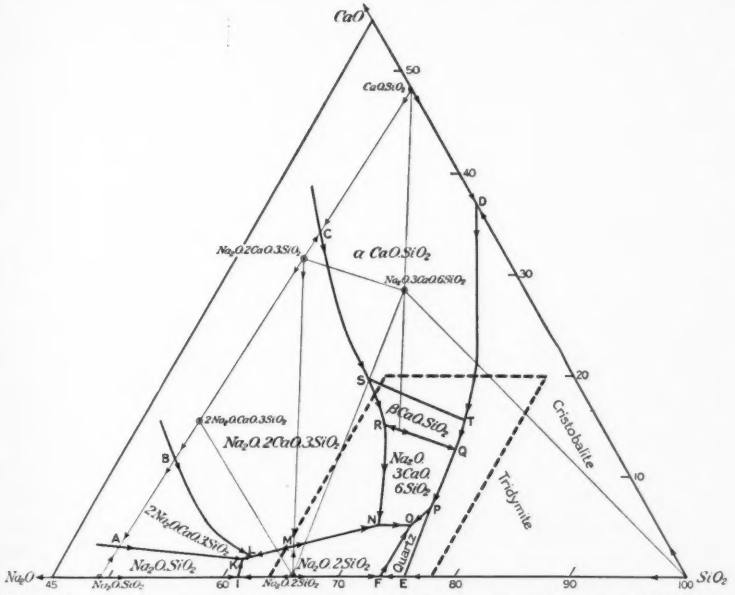


FIGURE 3.—EQUILIBRIUM DIAGRAM OF TERNARY SYSTEM $Na_2O{\cdot}SiO_2$–$CaO{\cdot}SiO_2$–SiO_2, SHOWING BOUNDARY CURVES AND TIE-LINES

into the interior of the diagram by coördinate lines parallel to the sides. This method of representing composition in a system of three components has the advantage of symmetry, and is more convenient except when one component is present in preponderant amount, as is frequently the case with water and salt systems. The other variable, temperature, is represented by erecting a prism on the triangular base, in which the heights from the base are proportional to the temperature. Figure 4 is a sketch of such a solid model. It consists of several mountain peaks and slopes, which intersect in valleys, which in turn run down to two deep sinks, the two ternary eutectics. In Figures 2 and 3 are shown the projections of

these valleys on the triangular base, and in Figure 2 are shown the projection of the curves obtained by passing horizontal planes, representing various temperatures, through the solid model.

Consider now Figure 3. It is divided by heavy curved lines, the projections of the boundaries between the various mountain slopes, into several fields, and the direction of falling temperature is indicated by arrows. Within each of these fields a different substance is the first to crystallize on cooling, or is the last to dissolve on heating. For example, from all mixtures whose compositions lie within the area *BCSRNML* the compound $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ is primary phase. As the liquid is cooled, and more and more of this compound separates, the composition of the residual liquid changes, and since the crystals and the residual liquid are being formed out of the original liquid, all three compositions must lie on a straight line, with the composition of the original liquid between the other two; and the relative amounts of the two phases will be inversely proportional to the lengths of the two parts of this line. As crystallization continues, the composition of the liquid will be continuously displaced along a straight line radiating out from the composition of $Na_2O{\cdot}2CaO{\cdot}3SiO_2$, until that line intersects one of the boundary lines between the fields. At that intersection, a second crystalline phase makes its appearance, and the system becomes monovariant. Within the field of any compound, the system is divariant, which means that at any temperature a large number of different liquids may coexist with the solid phase, and that fixing the temperature does not automatically fix the composition of the liquid. But when the system becomes monovariant, the composition of the liquid is fixed when the temperature is fixed, and at any given temperature only one liquid composition can coexist with the two crystalline phases. If the original liquid can be made up of the two crystalline phases that separate at the boundary curve, for example, if it lies on the line joining $Na_2O{\cdot}2SiO_2$ with $Na_2O{\cdot}2CaO{\cdot}3SiO_2$, at point *M*, then it will freeze entirely at this point, and the mixture may be regarded as a binary system within the ternary system. If it does not happen to occupy this unique position, for example, if it lies at a higher SiO_2 content than corresponds to the above line, then some liquid will be left over, and the composition of the liquid will follow the boundary curve in the direction of falling temperature, and in the case illustrated the liquid will follow the curve *MN*. What happens to it after it reaches *N* will be considered later.

It will be observed that the composition of the compound $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ lies within the field of this compound; a liquid of this composition will freeze completely to this compound when cooled, and when the compound is heated it shows a sharp melting point. Such a melting is called congruent. Within the same field is shown the composition of another compound, $2Na_2O{\cdot}CaO{\cdot}3SiO_2$, but the field of this compound is represented

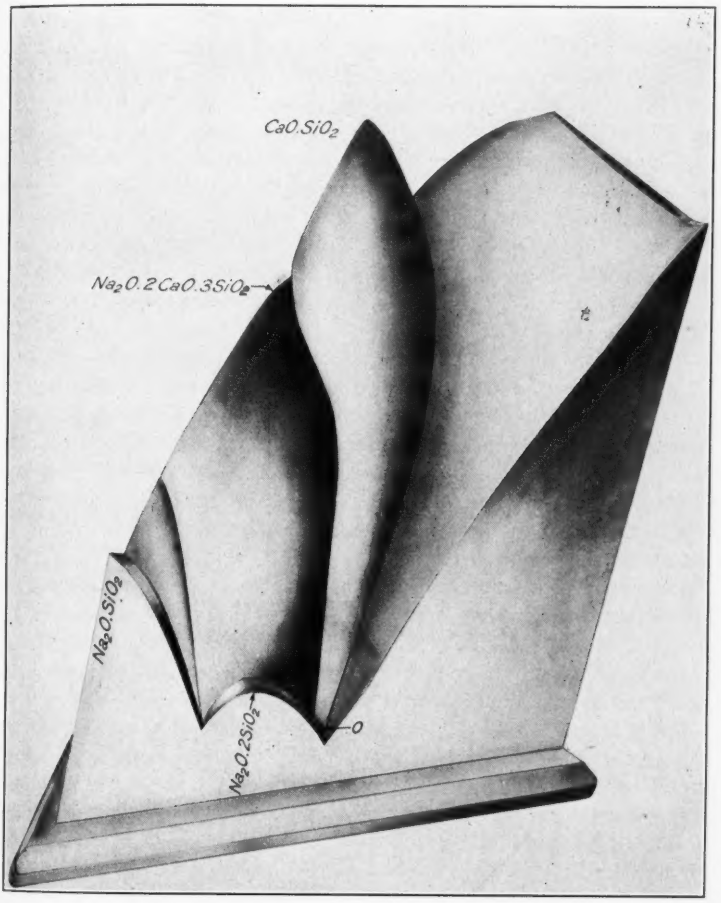


FIGURE 4.—SKETCH OF SOLID TEMPERATURE-COMPOSITION MODEL OF THE TERNARY SYSTEM Na_2O·SiO_2–CaO·SiO_2–SiO_2

by the area *ABLK*. Only from mixtures within this field does $2Na_2O$·CaO·$3SiO_2$ crystallize as primary phase. When the pure crystalline compound is heated it remains unchanged until the temperature of the point *B* is reached. Then it begins to decompose into a liquid of the composition *B* and Na_2O·2CaO·$3SiO_2$, and above the temperature, and at the liquidus, the latter compound is the crystalline phase coexisting with liquid. Such a melting is called incongruent, and the phenomena taking place at this point are entirely analogous to those which take place at the

transition point of a salt hydrate. When $Na_2SO_4 \cdot 10H_2O$ is heated at its transition point it decomposes into anhydrous Na_2SO_4 and saturated solution. In the binary system H_2O–Na_2SO_4 this is an invariant point, and indeed it is a fixed point whose equilibrium temperature is known to a high degree of accuracy. But if excess of either H_2SO_4 or NaOH be present the temperature is no longer fixed, but is monovariant; the transition temperature of the hydrate will be lowered in either acid or alkaline solutions. The case is exactly analogous in the silicate system. Point *B* is an invariant point in the binary system $Na_2O \cdot SiO_2$–$CaO \cdot SiO_2$, but is only one point on the curve *BL*, the monovariant equilibrium $2Na_2O \cdot CaO \cdot 3SiO_2$–$Na_2O \cdot 2CaO \cdot 3SiO_2$–liquid. It is, however, a point of maximum temperature along this curve.

Of the two ternary compounds already considered, one has an incongruent, the other, a congruent, melting point. But the one with a congruent melting point undergoes unusual dissociation in the liquid phase, as is shown by the shape of its melting-point curve. It will be remembered that $Na_2O \cdot 2SiO_2$ also possessed this property, and, indeed, it is characteristic of all the binary and more complex compounds which are met with in the glass field. A third ternary compound is met with in this system, of the composition $Na_2O \cdot 3CaO \cdot 6SiO_2$, and it is an extreme case of a compound with an incongruent melting point. The pure compound decomposes at 1060° into liquid and crystals of $CaO \cdot SiO_2$, and the melt does not become entirely liquid until 1325°. This compound is characterized by an extreme reluctance to crystallize, and every composition in which it is primary phase is a practical glass composition on a manufacturing scale. Its field is shown in Figure 3 by the area *NOPQR*, and on a larger scale in Figure 5, which includes only compositions from 64 to 78% SiO_2, 0 to 20% CaO, by weight. This diagram is constructed with rectangular coördinates, and may be regarded as derived from the rhombus indicated by broken lines in Figure 3 by means of a shear. The melting relationships are, however, more evident to the eye when Figure 3 is used. Practically all commercial soda-lime glasses are included within this area, and almost every mixture within this region on crystallization would solidify finally at the ternary eutectic at *O*, at a temperature of 725°. It will be instructive to trace out some of the crystallization paths.

Consider first a composition within the field of $Na_2O \cdot 2CaO \cdot 3SiO_2$, such that the crystallization path intersects the boundary curve *CSRN* between *S* and *R*. The secondary crystallization will be $CaO \cdot SiO_2$, and the composition of the liquid will follow the boundary line to *R*. At this point there will be a reaction between liquid and solid phases, with formation of $Na_2O \cdot 3CaO \cdot 6SiO_2$; and, since three solid phases and one liquid phase at constant pressure constitute an invariant point, the temperature will remain constant until only two solid phases, $Na_2O \cdot 2CaO \cdot 3SiO_2$ and Na_2O-

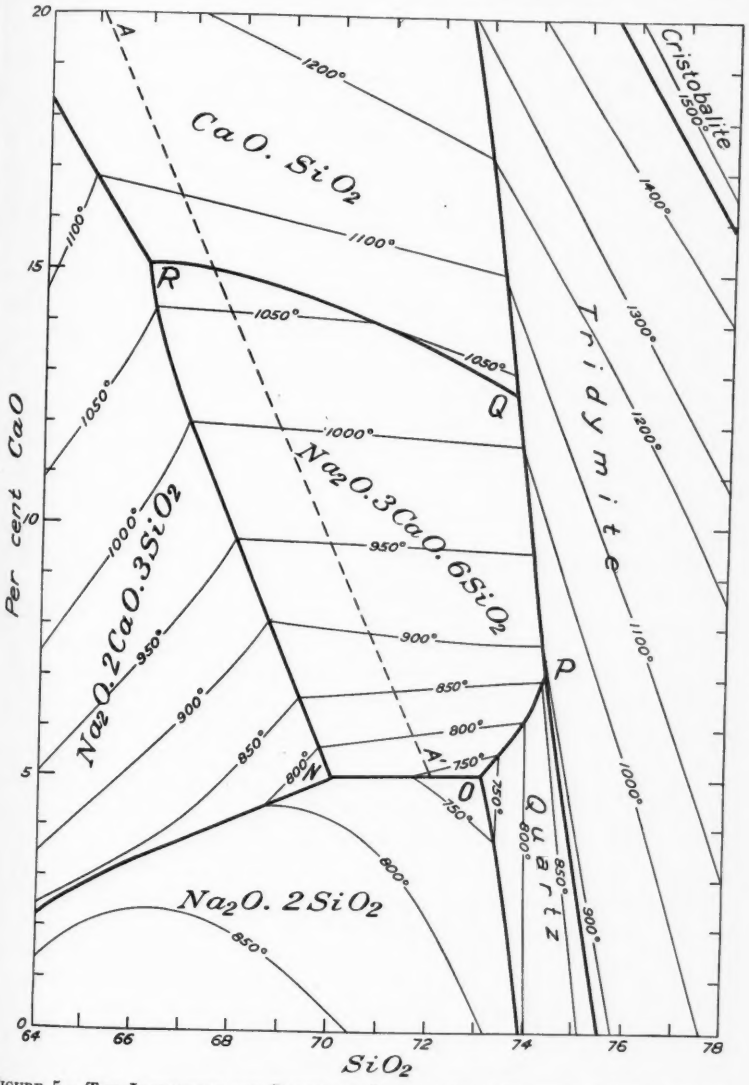


FIGURE 5.—THE ISOTHERMS AND BOUNDARY LINES IN THAT PORTION OF THE TERNARY SYSTEM Na_2O–CaO–SiO_2 OF INTEREST IN GLASS TECHNOLOGY

Weight % SiO_2 is indicated along the horizontal axis; weight % CaO along the vertical axis; weight % Na_2O is obtained by subtracting the sum of CaO and SiO_2 from 100%.

$3CaO{\cdot}6SiO_2$ remain. Such are the requirements of equilibrium, but in the portion of the system under consideration equilibrium is hard to attain, and especially when that involves formation of $Na_2O{\cdot}3CaO{\cdot}6SiO_2$. In practice, the boundary *SRN* is easily passed, and the invariant point *R* still more easily. To convert all the $CaO{\cdot}SiO_2$ into the stable $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ would require heating for an impracticable time.

If the conversion is completed, or if the intersection with the boundary *CSRN* takes place between *R* and *N*, the liquid will follow the curve to point *N*, the same point previously mentioned as reached by crystallizing a mixture whose crystallization path intersected the boundary *MN*. This also is an invariant point, and equilibrium requires that temperature remain constant until all of the $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ has been transformed into $Na_2O{\cdot}2SiO_2$ and $Na_2O{\cdot}3CaO{\cdot}6SiO_2$, with the sole exception of mixtures lying within the triangle $Na_2O{\cdot}2SiO_2$, $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ and $Na_2O{\cdot}3CaO{\cdot}6SiO_2$. When solidification is complete in a ternary system, there must be three crystalline phases, unless the composition has been so chosen that it lies on a binary join, as was seen to be the case at *M*, or unless it has the composition of a compound. Within the restricted composition region under consideration there is a small area within the above-mentioned triangle. When the liquid phase has followed *MN* to *N*, reaction takes place between liquid and $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ with formation of $Na_2O{\cdot}2SiO_2$ and $Na_2O{\cdot}3CaO{\cdot}6SiO_2$; and, since the original composition was assumed to lie within the triangle formed by the three crystalline phases, the liquid will be exhausted while $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ remains, and the mixture will freeze completely. But if the gross composition does not lie within this triangle, $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ will be used up while liquid still remains, and the resulting mixture of $Na_2O{\cdot}2SiO_2$ and $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ will follow the curve *NO*, to the eutectic at *O*. That would be the sequence of events if equilibrium were reached; but as the temperature is lowered the liquid becomes more and more viscous, crystallization and reaction become slower and slower, and to obtain equilibrium is a matter of the greatest difficulty.

A mixture whose primary phase is $CaO{\cdot}SiO_2$, and whose crystallization path intersects *RQ* should undergo reaction when this boundary is reached, and, depending on the original composition, the residual liquid will follow this boundary curve to either the invariant point *R*, in which case it will follow *CSRN* down to *N*, thence to *O*, or to the invariant point *Q*, in which case it will follow the boundary *QPO*, arriving at the same eutectic. If the original composition lies within the field of $Na_2O{\cdot}3CaO{\cdot}6SiO_2$, the crystallization path will intersect *RN*, in which case $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ will be secondary phase, and the liquid will follow the boundary to *N*, then react to form $Na_2O{\cdot}2SiO_2$, and finally run down *NO* to *O*; or the intersection will lie on *NO*, and $Na_2O{\cdot}2SiO_2$ will be secondary phase; or the intersection will lie on *QPO*, and either tridymite, from *Q* to *P*, or quartz

from *P* to *O*, will be secondary phase. But anywhere within this area crystallization is hard to induce, and the glass can be manufactured in ton lots without devitrification troubles.

Any composition more siliceous than the boundary *DTQPOF* will have a form of crystalline silica as primary phase, and as the silica separates the liquid will follow a path on the straight line through the SiO_2 apex and the original composition, until a boundary is reached. If the boundary intersected is between *D* and *Q*, $CaO{\cdot}SiO_2$ will be secondary phase, and when *Q* is reached equilibrium demands that all of it be transformed to $Na_2O{\cdot}3CaO{\cdot}6SiO_2$, and the liquid then follow the curve *QPO*. If the boundary is met below *Q*, $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ is secondary phase, and the liquid will follow the same path to the eutectic at *O*. But the remarks previously made in regard to the difficulty of attaining equilibrium apply with added weight to this region. Glasses near *QP* are difficult indeed to induce to crystallize at all; and to secure complete equilibrium is next to impossible. Indeed, the best composition for a glass composed of Na_2O, CaO, and SiO_2 is either near to, and to the right of, the line *PQ* or within the field of $Na_2O{\cdot}3CaO{\cdot}6SiO_2$. As has been said, the latter compound is characterized by extreme reluctance to crystallize, and the field of practical glass compositions is almost coincident with the field of $Na_2O{\cdot}3CaO{\cdot}6SiO_2$. One reason for this may be the fact that the field of this compound is far removed from its composition, and for crystals to form requires a considerable amount of molecular movement.

We have seen, then, that the region of commercial glass compositions is essentially that of the compound $Na_2O{\cdot}3CaO{\cdot}6SiO_2$, and that the temperatures in this region range from 1060° to 725°, and we have the answer to why glass behaves like glass. Mixtures within this area are above their freezing temperature throughout their working range; that is, during the processes to which glass is subjected in manufacture it is above the temperature at which devitrification can take place. But depart but a few per cent from a restricted field, and this is no longer true. As soon as the glass enters the field of silica, of $CaO{\cdot}SiO_2$ or of $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ the temperature increases rapidly, and crystallization takes place much more readily, hence the glassmaker must keep his compositions within narrow limits. He is aided, however, by another factor; he is never working with pure soda-lime glasses, even though he may call them such, but always has present several per cent of other oxides, derived from solution of the fireclay melting pots or contained in the original raw material. The effect of each of these impurities is to lower the melting point; for example, replacement of one per cent of CaO by Al_2O_3 lowers the melting point almost 100°. The story of the discovery of the advantage to be gained by the addition of alumina is an interesting one. It was a matter of common knowledge that while most glass devitrified easily before the blowpipe, glass made in

the Thuringian Forest remained clear and transparent, and the difference was ascribed to some secret formula. But an investigation by Schott (*4*) showed that the sand used contained almost four per cent of alumina and that addition of alumina to the usual batches greatly improved the product. We can explain this now; the alumina lowered the melting point, and brought the glass into the field of the $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ compound, which is characterized by small tendency toward crystallization.

We have seen that all the compounds which can be considered as probable constituents of glass are characterized by extreme dissociation. Sodium disilicate and $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ are compounds the atoms of which are firmly enough bound together to have congruent melting points, but these two stand out among all silicates by reason of the extreme flatness of their melting surfaces. The other two compounds, $2Na_2O{\cdot}CaO{\cdot}3SiO_2$ and $Na_2O{\cdot}3CaO{\cdot}6SiO_2$, are decomposed long before their melting points, and $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ is an extreme case of incongruent melting. It is certain, then, that these compounds cannot exist to any great extent in glass; we must look to simpler combinations, probably to a large extent to orthosilicates and to silica itself, as the molecular constituents of glass.

Commercial Glass Types

Most commercial glassware is of the soda-lime type, and a number of such glasses are included in Table II. The preponderance of the soda-lime type is due largely to the abundance and cheapness of its raw materials, but many glasses are made which differ widely in composition from the soda-lime type. Indeed, in considering the devitrification of glass, it is well to bear in mind that the chemistry of silicates differs not in kind but only in degree from that of the more usual compounds. Those particular compositions of matter which have been hit on for glasses have the common characteristic that they exhibit a great reluctance to pass from the liquid to the crystalline condition even under the most favorable circumstances, a characteristic possessed in a less or even a greater degree by many substances wholly unsuitable for use as glass. Many organic substances fall in this category, of which glucose solutions may be taken as an example. Some complex sulfate solutions may be obtained in a glassy form; As_2O_3 and Sb_2O_3 can both be obtained as glass, as can some of their compounds; phosphates are well known as glass formers, and indeed, the so-called meta- and pyro-phosphoric acids probably are only known in the glassy condition; and the oxide B_2O_3 has never yet been obtained in the crystalline condition. Among silicates, glasses of the composition of the minerals albite and orthoclase are far more resistant toward crystallization than any commercial glasses. The phenomenon of undercooling is a usual observation with molten salts, and the glasses of commerce

TABLE II
Composition and Optical Properties of Some Commercial Glass Types

TABLE II

Composition and Optical Properties of Some Commercial Glass Types

No.	SiO_2	B_2O_3	Na_2O	K_2O	CaO	BaO	ZnO	PbO	MgO	Al_2O_3	Fe_2O_3	As_2O_5	n_D	$\gamma = \frac{n_D - 1}{n_F - n_C}$
1	80.75	12.00	4.10	0.10	0.30					2.20		0.40	1.475	63.6
2	79.57		0.66	11.60	7.80				0.11	0.32	0.04			
3	73.1		14.0	1.0	12.0								1.523	59.0
4	72.86	10.43	9.82	0.10	0.35				0.20	6.24	Tr.		1.500	64.7
5	71.88		15.87	1.98	4.90				0.20	2.75		0.10		
6	72.15	5.88	5.16	13.85	2.04				0.07	0.04	0.01	0.20	1.511	64.0
7	69.58	9.91	8.44	8.37	0.07	2.54			0.07	0.04	0.01	0.32	1.516	64.0
8	69.30		12.80	4.96	8.28				0.07	4.05	0.18	Tr.		
9	68.69		15.87	7.32	5.66				0.24	2.11				
10	67.3	2.0	14.0		7.0		7.0			2.5				
11	66.90	7.22	1.25	2.40	7.94	7.27			0.61	6.38	0.2			
12	64.7	10.9	7.5	0.37	0.63		10.9		0.21	4.2	0.25	0.14	1.508	60.4
13	62.6		4.5	8.5				24.1				0.3	1.541	46.9
14	45.64		1.77	8.66	0.05			43.45		0.03		0.22	1.614	36.9
15	45.2			7.8		16.0	8.3	22.2				0.4	1.604	43.8
16	40.0		0.5	6.5				52.6				0.3	1.650	32.2
17	34.5	10.1				42.0	7.8			5.0		0.5	1.610	57.4
18	20.0							80.0					1.905	21.7
19		69.1	8.0			4.7				18.0		0.2	1.507	61.4
20		42.8						52.0		5.0		0.2	1.666	39.2
	P_2O_5													
21	70.5	3.0		12.0					4.0	10.0		0.5	1.516	70.3
22	56.0	3.0				38.0				1.5		1.5	1.567	65.6

1. Pyrex laboratory ware.
2. Kavalier combustion tubing.
3. Ordinary crown.
4. Borosilicate thermometer tube, Jena 59^{III}.
5. A good French lamp-working tubing.
6. Borosilicate crown, Jena O 144.
7. Borosilicate crown, Jena O 3832.
8. A good German lamp-working tubing.
9. Inferior Thuringian glass.
10. Jena normal thermometer tubing, 16^{III}.
11. Jena combustion tubing.
12. Jena Geräte ware.
13. Light flint, Jena O 726.
14. Ordinary flint, Jena O 118.
15. Barium flint, Jena O 1266.
16. Heavy flint, Jena O 102.
17. Heaviest barium crown, Jena O 1029.
18. Heaviest silicate flint, Jena S 208.
19. Light borate crown.
20. Borate flint.
21. Light phosphate crown.
22. Phosphate crown.

represent mixtures in which not only is this property of undercooling to form glasses strongly marked, but in addition the resulting glasses possess other properties which make them useful. Some entirely silicate-free glasses have been articles of commerce, and four such are included in Table II, Nos. 19–22. Nos. 19 and 20 are borate glasses, a crown and a flint, while Nos. 21 and 22 are phosphate glasses. These glasses were not sufficiently resistant to weathering and were withdrawn by the makers.

The first glass in Table II (*5*) is Pyrex laboratory ware, which is noteworthy for its low coefficient of expansion, and has become the standard laboratory glassware. The second is Kavalier combustion tubing, long a standard for extreme high temperatures, and still unexcelled, although when heated too hot it is apt to crystallize (*6*). Glasses Nos. 4 and 10 are special glasses developed for making thermometers free from troublesome shift of the zero point. Nos. 11 and 12, Jena combustion and Jena laboratory, are also well-known types of glass.

Nos. 5 and 8 are glasses which have proved excellent for lamp-working purposes, and No. 9 is an inferior type. It can be seen from Figure 4, considering only SiO_2 and CaO, that No. 5 is inside the $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ field, near the $Na_2O{\cdot}2SiO_2$ boundary, and if pure would be difficult to crystallize, although somewhat too rich in alkali to withstand weathering. But part of the alkali being K_2O helps to overcome this defect, and the Al_2O_3 content has a similar effect. No. 8 likewise is within the $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ field. If it were a pure lime-soda glass it would be good, although, because of its higher liquidus temperature, apt to devitrify on prolonged working. But this defect is completely overcome by the large proportion of alkali as K_2O, as well as the large Al_2O_3 content. No. 9 is, however, in the $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ field, with a liquidus as high as No. 8 when both are considered as pure lime-soda glasses. But the Al_2O_3 content is here not large enough to bring the glass into the $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ field, and it will devitrify easily.

Most of the other glasses in the list are primarily for optical purposes, although No. 13 is also a fair representative of the "lead" glass tubing used in the laboratory; its use, however, has greatly diminished in recent years. Some optical properties of the glasses are also given in Table II, and by measurements of refractive index the various glass types are readily distinguished. The properties given are the refractive index for the D line, and a quantity which is inversely proportional to the dispersive power of the glass, the ν-value. This is given by the difference in refractive index between glass and air, $n_D - 1$, divided by the dispersion, $n_F - n_C$. This quantity enters directly into the calculation of the lens design. Glasses 3, 13, 14, 16, 18 are members of the ordinary crown-flint series of the optical designer, and were all that were available until the introduc-

tion of the borosilicate crowns, illustrated by Nos. 6 and 7, and the barium crowns and flints, illustrated by Nos. 15 and 17.

The terms "crown" and "flint" need explanation. "Crown" glass was originally a flat glass, whose manufacture was a crown monopoly, and "flint" glass was any clear, transparent glass, and got its name from the use of a good grade of flint as a source of silica. This use of flint still persists in the designation of any clear bottle or container glass as a flint, but in general these terms have received a different and specialized meaning. A crown is a glass whose dispersive effect on the spectrum is relatively small, while a flint is a glass of high dispersive power. Flints are almost exclusively glasses containing PbO, and No. 18 represents about the extreme limit of such glasses. The flint glasses are the only ones whose derivation from the typical soda-lime glass is not evident. The melting-point relations in the alkali-lead oxide-silica system have not been worked out, so the details are not clear; but, just as the lime glasses may be regarded as derived from the $Na_2O{\cdot}2SiO_2$–quartz eutectic by the addition of CaO, or of $CaO{\cdot}SiO_2$, so the flints may be regarded as derived from the corresponding potassium silicate–quartz eutectic by the addition of $PbSiO_3$. Most flints contain K_2O, instead of Na_2O, because of the less harmful effect of Fe_2O_3 on the color of potash glasses. In the K_2O system, a third compound, $K_2O{\cdot}4SiO_2$, appears between $K_2O{\cdot}2SiO_2$ and quartz, but the field of the compound is narrow, and its temperature is low. Glass No. 18 has almost the composition of the compound, $PbO{\cdot}SiO_2$; and the flint series differs from the crowns in that, while $CaO{\cdot}SiO_2$ has a high melting point, at which it crystallizes so freely that it can onlv be made in gram lots, $PbO{\cdot}SiO_2$ has a low melting point, and itself can easily take on the glassy form. But the intermediate details are still unknown.

Much of our knowledge of the newer glass types has come in an attempt to improve optical systems, especially the microscope and photographic lenses. A lens made of but one kind of glass produces a colored image, because the refractive power of a glass varies with the wave-length of light. If a lens is exactly in focus for sodium light, it will be out of focus for red and violet, and the image will have colored fringes. By making lenses of two different kinds of glass, one having a much greater dispersive power than the other, this chromatic aberration can be overcome, and such achromatic lenses are widely employed. In calculating achromatic systems, it is customary to correct for two spectral lines, the C and F; but, unfortunately, this is not enough. The variation of dispersion power with wave-length is not exactly the same for all glasses, and a lens system may have perfect compensation for the C and F lines, and marked chromatic aberration at the photographically important G′ line. It is possible to correct for this additional line, and lenses so corrected are known as apochromatic. In the usual run of the ordinary crown

and flint glasses, dispersion and refractive index have practically a linear relation, and the lens designer has but little leeway, for it must be remembered that chromatic aberration is only one of the defects that must be overcome. Marked improvements in lens design resulted from the introduction by Schott of glasses containing B_2O_3 and BaO. The borosilicate crowns, of which Nos. 6 and 7 are typical, have a spectrum lengthened in the red, and are specially adapted to achromatizing the flints, in which the relative dispersion in the blue exceeds that in the red. The barium glasses combine high refractive index with low dispersion, and are specially adapted to the manufacture of high-speed photographic lenses.

Properties of Glass

When glass is freely cooled from the temperature at which it is fluid enough to work, a temperature difference is set up, which persists while the glass is hardening, and when the glass finally acquires a uniform temperature a condition of strain is set up. An extreme example are the "Prince Rupert drops," obtained by pouring glass into water. These are extremely hard, but if the tip is once broken the strain is explosively released and the entire drop shatters into dust. It is customary to remove strain by an annealing process, which consists in holding the glass at such a temperature that strains are relieved in a reasonable time, then cooling the glass slowly enough so that no more strains are set up. The relief of strain necessitates a certain minimum fluidity, and, since the fluidity-temperature curve is a continuous one, an annealing temperature is not a uniquely defined point, as is the melting point, but one arbitrarily determined by definition. Hence, "annealing temperatures" as determined by different observers do not necessarily mean the same thing, and, unfortunately, it is not possible to give a table of annealing temperatures. Pyrex glass will completely anneal at 550° in a few hours, while strain is immediately removed from No. 3 at 573°, No. 15, at 454°; and the temperature of 495° for No. 7 corresponds to still another definition of annealing temperature.

Other arbitrarily defined temperatures have been proposed for the characterization of glass, in view of the absence of a true melting point. The "softening" temperature of 815° as determined on Pyrex refers to the temperature at which a rod 0.6 mm. in diameter and 9 in. long lengthens under its own weight at the rate of 1 mm. per minute. The cohesion temperature has been defined as the lowest at which 2 plane polished pieces, 2 mm. thick and 10 mm. diameter, will coalesce in 30 minutes. Illustrative values of the cohesion temperature for 2 glasses of Table II are: 7, 583°; 14, 486°. The deformation temperature is defined as the lowest temperature at which, after 6 hours' heating, one observes a deformation of the polished faces of a 20-mm. cube embedded in kieselguhr with one diagonal vertical, and its value for No. 7 is 605°, for No. 91, 460°. Such arbi-

trarily defined temperatures are, of course, indirect methods of estimating points on the viscosity-temperature curve, and the softening temperature as defined for Pyrex has been found to correspond to a viscosity of 3.2×10^7 poises. Similarly, the annealing temperature corresponds to a viscosity of 5.6×10^{12} poises, while the glass is best gathered from the pot for working at a viscosity of 300 poises. These values will convey more information when it is remembered that the viscosity of water at 20° is approximately one poise, that of glycerin at 20°, 8 poises, and at 2.8°, 42.2 poises.

Laubengayer (*7*) determined the collapsing temperatures of a number of glass tubes, under atmospheric pressure, and evacuated to 3 mm. pressure. Temperatures were quickly raised to 300°, then 3° per minute until the tubes collapsed. Glass No. 1 is a soft soda-lime, No. 2, a "resistance" glass, No. 3, Pyrex, No. 4, Jena combustion, No. 5, Bohemian combustion, and No. 6, Moncrieff combustion. The composition of some of these is given in Table II; No. 5 is probably about the same as No. 2 of Table II. Number 6 devitrified readily.

TABLE III

Collapsing Temperatures of Glass Tubing

Glass No.	*Collapsing Temperature*	
	Open	*Evacuated*
1	700	585
2	750	635
3	820	670
4	860	720
5	860	740
6	820	770

The strength of glass is so greatly influenced by its thermal history and by the condition of its surface that the values given for it must be accepted with caution. The strength of a few common glasses is included in Table V. The following table summarizes data obtained by Onnes and Braak (*8*) on the bursting strength of glass tubing. The soda-lime glass used was of unknown composition. The maximum fiber stress, given under T_m, was calculated from the formula

$$T_m = \frac{1}{4}\left[5P_m + 7\left(\frac{P_m - 1}{\left(\frac{R}{R'}\right)^2 - 1}\right) - 1 \right]$$

in which P_m is the bursting pressure, R and R' the external and internal radii, respectively. The unit of pressure is the bar = 10^6 dynes per sq. cm.

The various physical properties of glass are frequently needed in connection with chemical problems, and some information in regard to them is assembled in Table V. It should be remembered that many of the prop-

TABLE IV

Bursting Strength of Glass Tubes

Shape of Tubes	*Range of Radii, R, Mm.* External R	Internal R'	*Number Tubes Tested*	*Range of Bursting Pressures,* P_m	*Max. Fiber Stress,* T_m	*Mean Var. from Mean, %*
Thick-walled....	9–18	3–6	9	230–380	470	14
Capillary.....	5–7	0.24–1.0	16	420–1200	902	27
Thin-walled....	3.8–7.8	3.4–7.3	17	54–377	628	20

erties of glass are functions of their previous thermal history, and that the properties given refer to the particular specimen of the type which happens to have been measured. Another piece, of the same general type, may possess markedly different properties as a result of a different thermal history, or a minor difference in chemical composition.

TABLE V

Properties of Some Commercial Glass Types. Compositions and Optical Properties are given in TABLE II

No.	*Density* $G./Cm.^3$	*Young's Modulus*	*Poisson's Ratio*	*Tensile Strength*	*Compressive Strength*	*Thermal Expansion* $\frac{10^6\, l}{\Delta l\ \Delta t}$	*Specific Heat,* $G.\text{-}Cal./G.$
		Unit = 1 Kilobar = 10^9 Dynes/Cm.^{2} = 10^3 Bars					
		1 Bar = 14.50 Lb./In.^{2} = 1.01325 Atm.					
1	2.25	611				3.2 (19–350°)	0.20
2	2.370	711				5.90 (0–100°)	
6	2.47	731	0.210				
10	2.585	732	0.228			8.03 (14.6–92.2°)	
17	3.532	783	0.271	0.73	8.3		0.140
18	5.944	499	0.261	0.35	5.9	9.33 (24.5–84°)	
19	2.243	461	0.274	0.57	8.0	6.71 (14.4–94.4°)	0.218
20	3.691						0.136
21	2.588					9.30 (17.7–92.7°)	0.190
22	3.238		0.272				0.146

In general, it may be assumed that the various physical properties of glass are roughly additive functions of the compositions, and factors have been deduced for calculating the density, Young's modulus, strength, and specific heat from the composition. The properties of any glass may be roughly inferred from Table V, and if more accurate information is desired it is best to obtain them by experiment. The data in the literature are, as a whole, too meager, and obtained under too poorly defined conditions, using glasses whose composition was not definitely enough known to justify further discussion.

An important property which has not been considered is the thermal conductivity. There is, unfortunately, little reliable information on this subject. Table VI gives the thermal conductivity of three glasses whose compositions are given in Table II.

TABLE VI

Thermal Conductivity

	Mg.-Cal. Cm.$^{-2}$ Sec.$^{-1}$ (° C., Cm.$^{-1}$)$^{-1}$		
No.	−190°	0°	100°
7	1.195	2.825	
16	0.851	1.867	
21	0.877	1.796	2.007

Literature Cited

(1) NEUMANN, *Z. angew. Chem.*, **38,** 766 (1925); **40,** 963 (1927); **42,** 835 (1929).

(2) MOREY and BOWEN, *J. Phys. Chem.*, **28,** 1167 (1924); KRACEK, *ibid.*, **34,** 1583 (1930).

(3) MOREY and BOWEN, *J. Soc. Glass Tech.*, **9,** 226 (1924); MOREY, *J. Am. Ceram. Soc.*, **13,** 683 (1930).

(4) SCHOTT, OTTO, "Verh. des Vereins des Gewerbfleiss," **1887,** p. 799.

(5) Most of the data of Table II, as well as of the succeeding tables, are taken from "International Critical Tables," vol. 2, p. 87, "Properties of Glass," GEORGE W. MOREY.

(6) For the details of the K_2O–CaO–SiO_2 system, see MOREY, BOWEN, and KRACEK, *J. Soc. Glass Tech.*, **14,** 149 (1930).

(7) LAUBENGAYER, *Ind. Eng. Chem.*, **21,** 174 (1929).

(8) KAMMERLINGH ONNES and BRAAK, *Verslag. Akad. Wettenschappen Amsterdam*, **16,** 890 (1908).

Earth's Core Composed of Metallic Iron and Nickel. Though it sounds like an unsolvable riddle, perfection of modern scientific methods and instruments have wrested from the world that its core is formed of metallic iron with a little nickel. This conclusion, generally accepted among scientists, dashes speculation which has persisted to recent years that the earth, because it is heaviest at the center, has a heart of gold.

While not troubling to contradict this Jules Verne conception of fabulous wealth unattainably hidden in the middle of the globe, Dr. L. H. Adams of the Geophysical Laboratory of the Carnegie Institution of Washington tacitly refutes any golden dreams of the earth's interior in a recent report to the Engineering Foundation.

This earth is made up almost entirely of four elements, iron, magnesium, silicon, and oxygen, Dr. Adams says. And the remaining 88 elements (including gold, silver, and platinum) are confined to the thin film called the crust.

Directly beneath the relatively thin layer of sedimentary rocks at the surface, there is a first layer of granite ten miles thick; below that a twenty-mile layer of basaltic rock. Two thousand miles of peridotite rock (consisting of iron magnesium silicate) come next, while the central core of 4000 miles diameter is formed of metallic iron with a little nickel.

Earthquake waves yielded the important key to the secret of the earth's composition. Earthquakes of any considerable magnitude produce elastic waves, some of which travel along the surface of the earth and others pass through it. By measuring the acceleration and retardation of these waves on passing through the earth at various depths, the experts are able to judge what sort of rocks and minerals intervene. According to its elasticity, each different kind of rock has a different effect on the speed of the waves passing through it and so it is possible to judge the kinds of strata traversed.—*Science Service*

THE SCIENTIFIC CAREER OF HENRY LOUIS LE CHATELIER

RALPH E. OESPER, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

Henry Le Chatelier, scientist, teacher, writer, editor, though best known in academic circles for the principle which bears his name has made notable contributions to metallurgy, metallography, measurement of high temperatures, microscopy, ceramics, cements, chemical mechanics, combustion of gases, etc. He has pointed the way to the scientific attack of industrial problems and has preached the prime necessity for a closer union of pure and applied science.

. . . . . .

Ancestry and Education

The potency of heredity and environment is clearly discernible to the student of the careers of eminent scientists and Henry Le Chatelier presents an excellent example of the favorable influence of a scientific lineage and all that this normally brings into the home. His maternal grandfather, the architect Pierre Durand, was an intimate friend of Vicat and collaborated with him in studying the manufacture of hydraulic limes After Vicat's death Durand continued this work and one of Le Chatelier's earliest recollections was his terror of the roaring of his grandfather's experimental kiln which he, then only six, was once allowed to light. Durand took dinner with them almost every Saturday and critically quizzed his grandchildren on their lessons, rewarding them if their progress was satisfactory. These conferences were held with such solemnity that Le Chatelier and his brothers were early and indelibly imbued with the capital importance of making useful labors the aim of their lives.

Louis Le Chatelier (1815–1873), the father, was an accomplished engineer. He, an ardent Republican, resigned his government position when Napoleon III came to the throne and then became consultant for a large banking house. In this capacity he investigated such projects as the building of railroads in Austria and Spain, and establishment of steel works in Hungary. He published important papers on mechanical topics: the stability of locomotives, the utilization of steam, etc. The Martin process of making steel was really his invention but he was led to abandon his patent because of the poor quality of the furnace linings which melted during his experiments. He collaborated with Sainte Claire Deville on the extraction and applications of aluminum. He was closely associated with the scientific leaders of his time, particularly the chemists, and so at an early age Le Chatelier came to know Chevreul, Dumas, Sainte Claire Deville, Daubrée, Tresca, Morin, etc., not only as visitors to his home but also as the authors of the publications which came to his father's study and which were always available to the boys of the family. The five sons achieved considerably more than average eminence in their chosen professions. Henry Louis (1850–) is the subject of this paper; Louis (1853–1928), prominent metallurgist and industrialist, played a leading part in

the crusade against syphilis and with Vernes founded the Institut Prophylactique; Alfred (1855–1929), army officer and explorer, was an authority on the Moslem world, lectured on the sociology of these peoples at the Collège de France, the French North African policies owe much to him; Georges (1858–), architect, has done notable work in the restoration of churches and chateaux; Andre (1861–1929), metallurgical engineer, was well known for his outstanding studies of the properties of metals, the tempering of steel, mechanical testing, autogenous welding.

The work of Sainte Claire Deville particularly appealed to Le Chatelier and at a comparatively early age he became conversant with the phenomena of dissociation, and this at a period when most professors of chemistry knew little of this field. This special knowledge contributed greatly to his success in examinations, gave him a reputation as a chemist, and thus led to the orientation of his scientific career.

Le Chatelier received his early training in mathematics and chemistry from this gifted father who taught him not only facts but general viewpoints. Not the least of these was Poinsot's maxim: "A calculation can never yield more than was put into it at the beginning. If the premises are false, the conclusion cannot be better." Hence Le Chatelier's deep-rooted skepticism of many of the pronouncements of modern scientists, especially physicists, who starting with absolutely arbitrary hypotheses delude themselves with the notion that a complex mathematical structure, though built on a weak foundation, will of itself endow their speculations with validity.

At the age of ten, Le Chatelier's mother had been told that she was the victim of an incurable disease, and though she lived to the age of seventy-four, bore seven children and preserved her faculties to the end, she constantly suffered from imaginary nervous ailments. To her son she transmitted an extremely impressionable temperament, which was of great value to him as a scientist, making him keenly sensitive to new phenomena that so often appear unexpectedly in routine researches.

Her household was run on a strict schedule: the children rose at a specified time, completed their chores and prepared their lessons in good season, ate what was put on their plates, etc. As a result Le Chatelier all his life has had a profound respect for law and order. During his career, his interests were always directed toward the study of natural laws, their application to new cases, the deduction from them of new consequences. He never had the desire to overturn a law, and all his researches were animated by the desire to confirm and extend the work of his predecessors. This doctrine was preached to his students whom he admonished to walk softly in the sight of the builders of science, advising them to be content with adding a bit to the structure of knowledge, keeping their eyes open for anomalous results, but avoiding the error of systematically seeking sensa-

tional discoveries, which do not come by merely wishing for them. Yet Le Chatelier never sacrificed his freedom of thought, distinguishing clearly between discipline and liberty. The former he regarded as the voluntary respect for law, both social and scientific, the latter as the right to proceed against violation of law, that is, against error, injustice, arbitrariness.

Certain incidents of his school days not only show the impress of his temperament and home training, but they show the early development of his force of character. Shortly after he entered college, his history teacher imposed on him an enormous task as an undeserved punishment. Le Chatelier reacted by losing interest in all literary subjects and spent the time in these classes working on mathematics with the result that he led his group in mathematics and sciences, a fruit of purely personal effort with little or no guidance. During his last year in this school his mathematics teacher accused him of copying. Thoroughly incensed, Le Chatelier joined with two of his fellow students also unjustly treated, and they resolved to avenge the insults by proving the teacher to be incompetent. At the expense of considerable effort, they worked out and confronted this teacher with solutions of the problems assigned, far more elegant than his. At the École Polytechnique, Le Chatelier's independent cast of mind again evidenced itself. He joined with several other kindred spirits in projects totally outside the prescribed curriculum. In particular, they built up a course in physics, based on the positivism of Comte, eliminating all abstract entities such as force. These voluntary intellectual labors were of great benefit and in his educational creed he speaks from experience when he constantly insists on the fallacy of stuffing the student with facts and neglecting to inspire him to think independently and to develop general viewpoints.

During his three years as student at the École des Mines he repaired his deficiencies in the literary branches. He learned to speak on his feet in a student club devoted to discussions of the political and social questions of the day. He regularly attended the chemistry lectures of Sainte Claire Deville at the Sorbonne, and from him learned to hold in profound contempt verbose scientific postulates in which high-flown verbiage is used to conceal the paucity of sound ideas. This critical attitude has been his constant companion, and though contributing to his success it has also alienated the friendship of many scientists who regarded him as a refractory spirit because of his outspoken scorn of half-baked theories, no matter how fashionable. At the Collège de France he heard the lectures of Étienne Marey, the physiologist, and derived from these discussions of the flight of birds, a knowledge and appreciation of the scientific method.

When Le Chatelier finished his formal education he had no thought of becoming a man of science but planned to devote himself to mining engineering in the government service. He spent two years in the Corps

LE CHATELIER'S LABORATORY AT THE ÉCOLE DES MINES DE PARIS
In the center is Goutal, *chef de travaux*.

des Mines at Besançon and was astounded when he received an offer of the professorship of chemistry at the École des Mines. Daubrée, the director of this school, knew Le Chatelier's father well, but had no knowledge of the young man's chemical qualifications beyond the excellen. showing he had made in his examinations. Le Chatelier had done no original work in this field, but he resolved to demonstrate that Daubrée's choice was justified. He went to Sainte Claire Deville for advice as to the choice of a research topic, but his inquiry was met with laughter. "Set to work and soon so many problems will present themselves that your difficulty will not be to find a single subject worthy of study, but rather to eliminate most of the possibilities so that you may confine your efforts to the most interesting."

Le Chatelier's scientific career may be rather definitely divided into six periods which, though quite distinct, are linked together to a certain degree. The fields in which he chose to work were determined in great measure by his environment, but he was always wise enough to select problems of wide interest which gave promise of novel findings and of industrial applications. As a consequence his reputation as an authority was soon international. His success rests in great measure on his unwavering adherence to the scientific method, his use of common sense, his skill in analyzing

complex problems into their elementary components, his recognition of the dominant factors of the situations confronting him, his mode of attack by varying one factor at a time.

Cements, Measurement of High Temperatures, Chemical Mechanics

For his first investigation Le Chatelier, remembering his grandfather's efforts, chose to study the chemistry of hydraulic cements. A search of the literature revealed a tremendous lack of exact knowledge of these materials. Being totally inexperienced in research and having no guiding counsel, he decided to begin by repeating the experiments of Lavoisier and Payen on the preparation of plaster of Paris, not only to get his hand in, but because there are certain analogies between these classes of mortars. Much to his surprise, new and interesting facts came to light. Payen had stated that the gypsum should be heated to 300°, but Le Chatelier found that the proper temperature was 135°. He used the method of thermal analysis devised by Regnault and later applied to the study of the transformations of molten sulfur by Emile Sainte Claire Deville, a method then little known, but destined to play an important rôle in the study of steels and alloys. A slight irregularity in the heating curve led him to the discovery of a new hydrate, $CaSO_4 \cdot {}^1/_2H_2O$, which loses its water at 170°. Good plaster of Paris consists of this hydrate, and not of anhydrous calcium sulfate as was previously believed. He next repeated Lavoisier's experiments on the hydration of plaster of Paris. Recalling Marignac's observation that this material is about five times as soluble as hydrated gypsum, Le Chatelier developed a theory applicable to the setting of all hydraulic cements. In contact with water, a supersaturated solution is formed which deposits a less soluble hydrated material, this constant solution and deposition thus resulting in the production of an interlaced and coherent mass of minute crystals.

Le Chatelier reasoned that the difficulty hitherto encountered in the study of cements proper arose not from any extraordinary chemical properties but rather from their consisting of very intimate mixtures of a great variety of materials. By the judicious use of Sorby's microscopic petrographic methods he found that all cements contained a common constituent, $3CaO \cdot SiO_2$, whose composition he established. When moistened, this material did not merely add water but reacted:

$$3CaO \cdot SiO_2 + Aq = 2CaO \cdot SiO_2 \cdot 3H_2O + CaO \cdot H_2O$$

He also found that mortar which had been allowed to set out of contact with carbon dioxide contained large hexagonal plates of hydrated calcium oxide. From these findings he developed his theory of the hardening of cements.

The investigation of the calcining of raw cements led Le Chatelier to

restudy the dissociation of calcium carbonate, as Debray frankly admitted that his findings were only approximations. Almost immediately the lack of an accurate method of determining high temperatures became evident and Le Chatelier decided to attempt to use thermocouples, even though Regnault had condemned them as most inaccurate. Le Chatelier believed that the difficulty probably resided in the fact that temperature was not the only factor involved in the production of the current, and, once tracked down, these extraneous influences could either be eliminated or their effects nullified by a correction factor. Regnault had observed that the indications given by his couples varied with the depth to which they were immersed in the furnace and Le Chatelier tentatively ascribed this erratic behavior to parasitic couples developed during the heating, an hypothesis which was confirmed by locally heating iron and palladium, the metals used in the thermocouples employed up till then. Platinum and its alloys with rhodium and iridium were found to be faultless in this respect and the excellent platinum-platinum-rhodium couple devised by Le Chatelier is still widely used. The couples require frequent recalibration and his use of the boiling points of sulfur and naphthalene and the melting points of gold and platinum as fixed points reduced the time of precise calibration to a few minutes as contrasted with the relatively inexact results of the days of tedious labor consumed by the comparison with a gas thermometer. The determination of high temperatures is now a routine procedure and this great advance is largely due to Le Chatelier's intelligent attack of the problem. Some critics have disputed this claim, asserting that his success was due to the application of good sense rather than the fruit of scientific originality, but what scientific achievement has not been attacked on this score?

An outgrowth of his researches on cements were his applications of thermodynamics. This science, created by Sadi Carnot, had been extended to isolated phases of chemistry. Clapeyron had deduced a formula applicable to vapor tensions to which Clausius had given a rigorous mathematical treatment. The discovery of dissociation by Sainte Claire Deville opened up new possibilities. Peslin and Moutier pointed out that the Clapeyron-Clausius equation rested on the existence of equilibrium vapor pressures, and ought to apply also to the dissociation of calcium carbonate if this requirement was fulfilled. Josiah Gibbs deduced all the laws of chemical mechanics but the complicated mathematical structure of his papers effectually kept the chemical world in ignorance of his monumental achievements. Le Chatelier reasoned that thermodynamic considerations should yield general and valuable information about chemical phenomena, such as the solubility of salts, their reaction with water, etc. A long period of meditation was barren of results and Le Chatelier was about to abandon his idea when he remembered that Carnot's work

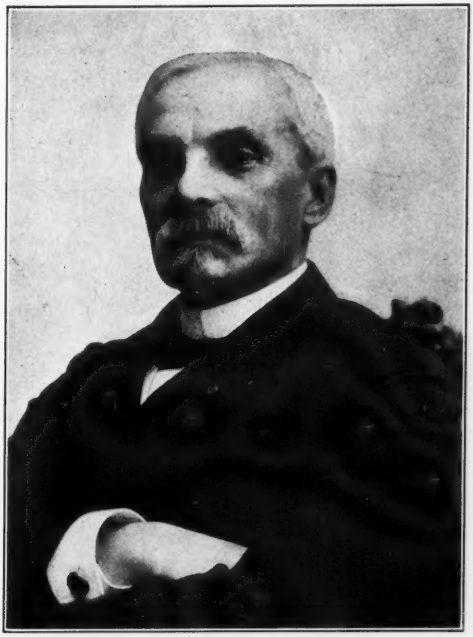
on the motive power of heat was based on three simple postulates: (1) the impossibility of perpetual motion; (2) the possibility of transforming heat into work; (3) the reversibility of this transformation—conditions which Le Chatelier recognized as holding rigorously in chemical reactions. Now certain of his ground, he attacked the problem with quickened enthusiasm and the result was his well-known principles of equilibrium, the displacement of equilibria, the general laws of solubility, etc., to which his name is attached and for which he is perhaps best known in academic circles.

Le Chatelier wrote: "These investigations of a rather theoretical nature are capable of much more immediate practical application than is ordinarily believed. Indeed the phenomena of chemical equilibrium play a capital rôle in all operations of industrial chemistry. Unfortunately there has been such an abuse of the application of thermodynamics that it is in discredit among experimenters"—an attitude that is undergoing rapid alteration. Van't Hoff was working on these lines concurrently with Le Chatelier and their findings overlapped. Although Le Chatelier's laws were expressed in the more rigorous form, van't Hoff brought forward a great mass of experimental data and consequently the latter is often erroneously given exclusive credit for the law of solubility, even though Le Chatelier had antedated him.

Combustion of Gaseous Mixtures—Ceramics and Glasses

The orientation of Le Chatelier's researches was abruptly altered in 1882. Serious disasters in the coal mines prompted the government to appoint a large commission to study means of preventing these explosions of fire damp. The work was divided among several sub-committees. Mallard, professor of mineralogy at the École des Mines, who had already made some studies of fire damp, was put in charge of the experimental work and he sought Le Chatelier's assistance. They outlined a program of procedure and their success was in large measure due to this preliminary planning. The authorities, in characteristic fashion, expected that a fool-proof preventive could be discovered, but the scientists knew this to be a vain hope. The safety of the mines is dependent on so many and so great a variety of precautionary measures, any one of which has only a slight influence on the final result, that the search for a panacea was almost certain to be fruitless. Le Chatelier and Mallard decided to make a scientific study of the combustion of methane, and as this was a new field, it seemed to give promise of results that might be applied to the main problem. They determined the temperature of ignition, the speed of propagation of the flame, the explosion pressure, etc. The rather expensive apparatus was now in good working order and as they had learned the technic they extended their studies to hydrogen, carbon monoxide,

acetylene, cyanogen. Valuable data and their consequent deductions were later incorporated in Le Chatelier's well-known book "Le Chauffage Industriel," a work which contains information of great importance on the efficient use of fuels. Le Chatelier designed two devices for detecting and determining small quantities of marsh gas; these were widely used and contributed to the safety of mines. He again revealed his remarkable common sense in suggesting that only two precautions need be taken: (1) keep the methane content below the danger point, (2) use lamps, explosives, electrical appliances of such type as do not ignite this gas. He reasoned that if each of these measures is disregarded one per cent of the time, the possibility of both being neglected simultaneously is only one in ten thousand. He and Mallard also developed suitable explosives. Their fundamental ideas were: (1) the chance of igniting the gas is lessened with lowering of the detonation temperature of the explosive, (2) detonating non-deflagrating explosives cool so rapidly because of the expansion of the gases formed that the fire damp has not sufficient time to reach its ignition temperature. These explosives, which have an ammonium nitrate base, have now been used in France for almost fifty years and similar compositions have found favor in other countries.



FRANÇOIS ERNEST MALLARD, PROFESSOR OF MINERALOGY AT THE ÉCOLE DES MINES DE PARIS

This association with Mallard was of great benefit to Le Chatelier, whose researches hitherto had been carried out under no guidance but his own innate ability. Mallard gladly acted as his preceptor and under his direction Le Chatelier learned to evaluate the precision of his experiments, to classify his findings, to deduce from them the most reliable conclusions, and above all not to be too hasty in publishing incompleted studies, a fault all too common among young scientific workers. Le Chatelier still makes

it a practice not to publish anything until he has written it at least three times.

Mallard was particularly interested in the allotropic transformations of crystalline materials and was studying the changes in the crystal systems produced by these transformations. He and Le Chatelier frequently discussed this topic. These transformations could be followed with the polarizing microscope only up to 200° to 300°, and Mallard requested his co-worker to devise a method that might be used at higher temperatures. Le Chatelier thought that determinations of the dilation would give the desired information. He accordingly contrived a very simple differential dilatometer which enabled him to observe the relative expansions of the specimen and the refractory on which it rested. The absolute expansion of the support was accurately measured by a rather complicated photographic method. Porcelain was found to expand quite regularly, in marked contrast to terra cotta and faïence, and it was adopted as the standard of comparison.

The differential dilatometer was tested by studying the thermal expansion of quartz rods cut from large crystals, either parallel or perpendicular to the principal axis. Fizeau had investigated the expansion of quartz below 100°, and Le Chatelier planned to carry this study up to 1000°. He confirmed Fizeau's findings but also discovered that at 570° there is an abrupt dilatation, in both directions, averaging 0.25%, which is most striking since porcelain only expands 0.4% between 0° and 1000°. Above 570° quartz actually contracts with rise of temperature. This sudden dilation indicated an allotropic transformation and Le Chatelier verified this by measuring the double refraction and rotary polarization. This transformation of α- to β-quartz explains the rupture of large quartz crystals when heated unless they are carried very slowly past this region. A similar study of the other varieties of silica disclosed the transformation of α- $\longrightarrow$ β-tridymite at 130°, and α- $\longrightarrow$ β-cristobalite at about 230°. Cristobalite was then considered a rarity and as such exhibited in museums until Le Chatelier showed that silica bricks consist chiefly of this material. He was the first to determine the thermal expansion of amorphous silica which he found to have a lower coefficient than any known material. Later studies dealt with the mechanism of the complex transformations of the numerous varieties of silica and he was able to prove that the excellent characteristics of silica bricks arise from the formation in them of a crystalline network of tridymite.

This specialized knowledge gave him an insight into some of the difficulties encountered in the manufacture of faïence. During the firing the silica is partially transformed into cristobalite which determines the expansibility of the biscuit ware and consequently the more or less perfect adhesion of the glaze. A study of the thermal expansion of glasses

logically ensued. It had hitherto been accepted that the expansion of glasses was a strictly additive property. Le Chatelier proved this was not the case and showed that this error arose from a faulty mathematical treatment of the experimental data. The fusion curves of glasses containing two constituents were not straight lines but exhibited well-defined minima. He later directed studies of the rapid firing and annealing of different varieties of glazes, the curious phenomena observed when glasses begin to soften, the industrial aspects of glass manufacture, etc.

Metals and Alloys

Le Chatelier's teaching opened a new era in chemical education. Enumeration of compounds, their properties, methods of preparation, such was the unappetizing content of the lectures usually offered to the students. He refused to follow this fashion whose effect was the alienation of the student's interest. His courses were built around general laws and principles and he presented facts only as applications of these. He stressed the value of these laws in predicting new facts and emphasized the necessity of precise measurements since these alone can lead to valid general conclusions. Never did he usurp the function of a dictionary or encyclopedia, and his sole object was to develop the reasoning power rather than the memory of those to whom he was unfolding the beauties of chemistry. Some critics said that he was teaching physics rather than chemistry, but the success of his students has effectually demonstrated the correctness of his educational policies.

About 1890 Le Chatelier planned to supplement his course on industrial chemistry by some lectures on the application of the general laws of physics and chemistry to metallurgy. He had no special knowledge of this field, the chemical courses he had attended had included little or nothing about alloys and a search of the literature soon convinced him that the information he desired was non-existent. Alloys were then regarded as glasses or as compounds of indefinitely variable composition, a view to which Le Chatelier could not subscribe. His reading led him to the conviction that alloys are heterogeneous aggregates of metals and compounds, analogous to rocks like granite, but with this important difference, that the constituents of alloys are so finely dispersed and so nearly alike in color that it is extremely difficult to distinguish them one from another. He published his opinions in an article in which he critically reviewed from this standpoint Sainte Claire Deville's isolation of definite compounds of metals of the platinum family, Matthiessen's studies of the electrical conductance of alloys, Cahour's findings relative to the densities of bronzes, and lastly Sorby and Osmond's studies of the metallographic constitution of alloys. His ideas were immediately accepted but, as they in some measure coincided with the vague notions previously put forth by others,

many have failed to give Le Chatelier just credit for laying the definite ground work of this modern theory of the constitution of alloys.

The best evidence in favor of Le Chatelier's views was furnished by the work of Osmond who had revived Sorby's microscopic metallography. Even at this time Le Chatelier felt that this technic was destined to become a valuable aid not only in the study of alloys by the pure scientists but also in industrial laboratories where it would be used side by side with chemical analysis and mechanical testing. This prevision has been realized, but at that time it was a daring prophecy for the difficulties of making this type of examination were so nearly insurmountable that Osmond openly discouraged those who wished to work along this line. "You will get nowhere! Bring your specimens to me and I shall gladly examine them for you."

Osmond accepted no students but he could hardly refuse to demonstrate his methods and point out its difficulties to Le Chatelier, for the latter had welcomed him when he came to Paris for instruction in the use of thermocouples. The apparatus was set up in Osmond's apartment, the preliminary grinding being carried out in his bedroom, the next stage in the dining room, while the drawing room was the scene of the final polishing. At each door was a supply of water and towels so that he could wash his hands and the specimen and he thus avoided carrying along traces of abrasive dust which might interfere with the succeeding operation. The well-polished specimen was taken to the laboratory to be photographed and final satisfactory results were usually obtained only after numerous adjustments and exposures.

The whole operation required not less than three hours, so Le Chatelier, who desired a procedure which his students might use in their industrial careers, decided to attempt to develop a simpler and shorter technic. The chief difficulty in the polishing of the specimen arose from dust and coarser particles of the abrasives. He completely eliminated this difficulty by working out efficient methods of levigation and grading and also found that alumina prepared by calcining ammonium alum is far superior to the iron oxide (calcothar) hitherto used for the final polishing. He protected his polishing powders from contamination by making them into pastes with soap which were then preserved in metal tubes until needed. Le Chatelier also contrived a microscope embodying an arrangement of diaphragms, etc., to cut off the light which does not contribute to illuminating the pertinent region of the specimen and thus overcame the effect of the aberrant light, the main source of Osmond's difficulties. He also worked out a simple method of casting in juxtaposition small quantities of two metals and so prepared convenient specimen systems containing two metals alloyed in all proportions from one pure metal to the other.

Thus armed, he began an extended study of alloys: their thermal ex-

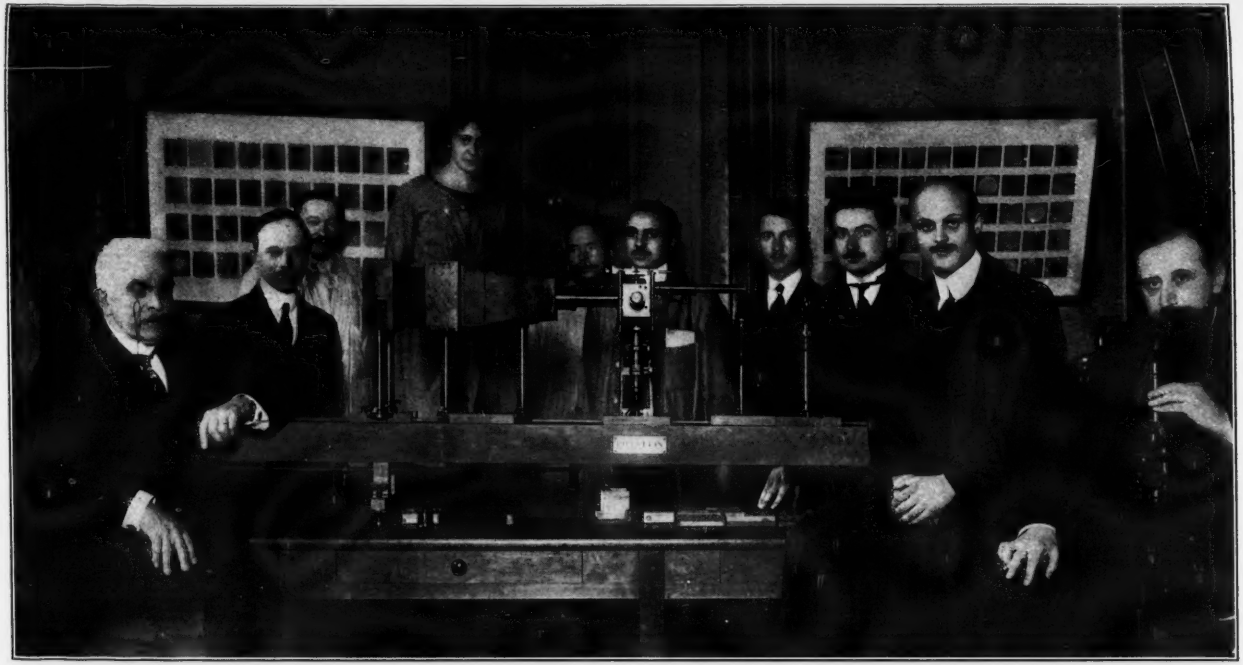
Laboratory of General Chemistry at the Sorbonne, 1909–10

pansion, electrical conductivity, thermoelectric potentials, cooling and heating characteristics, tempering, annealing. These data have been of inestimable value from an industrial standpoint, for they have not only led to the abandonment of empirical industrial procedures, but have also contributed much to the knowledge and interpretation of the constitution and allotropic transformations of a wide variety of alloys. His applications of the phase rule to these systems have been fruitful and like all of his pronouncements they are characterized by the fidelity with which they adhere to the experimental findings. He has always been interested in the mechanical testing of metals and he has taken an active part in the international congresses on this field.

Not the least of his services to the scientific progress of metallurgy was the creation of the *Revue de Metallurgie*. As early as 1894 he had felt that the French metallurgists were at a disadvantage because of the lack of a periodical comparable to *Stahl und Eisen* and the *Journal of the Iron and Steel Institute*. Believing that the diffusion of the knowledge of the scientific bases of metallurgy was most needed, his plan was to limit the subject matter to a review of this aspect of the field, but he could not secure financial backing. He was told that his project was inimical to the larger corporations for he was proposing to give their small competitors the benefits of the studies made in great plants. Only after ten years of determined effort was his educational campaign successful, a victory ascribable in great measure to his books, "Les Alliages Metalliques," "La Fragilité de l'Acier," "Les Argiles et la Ceramique." The *Revue* began its useful career in 1904, with Le Chatelier as editor, a post he occupied until 1914, when he resigned with the assurance that the venture had more than repaid him in satisfaction for all of the effort and toil he had expended in its founding and direction.

The Scientific Management of Work—Taylorism

In 1908, Le Chatelier was appointed to the chair of inorganic chemistry in the University of Paris, as successor to Moissan who had died on February 20, 1907. This honor came as a great surprise to Le Chatelier for he, an engineer, had had little contact with the academically minded university circles, in which the Polytechnicians were regarded with a certain degree of disdain. In fact, a regulation had been secured requiring resignation from the Corps des Mines of all appointees to the Faculties of Sciences, and though this law was usually honored in the breach, Le Chatelier frankly told Liard, rector of the university, that he would never consent to this betrayal of his profession. Liard said: "What we desire are your abilities. I do not know whether you are an engineer or not but I do know that you are a scientist and teacher, and that you will be an honor to the university."



LABORATORY OF GENERAL CHEMISTRY AT THE SORBONNE, 1920–21
Laboratory of Metallographic Microscopy.

Le Chatelier retained his chair in the École des Mines but resigned the professorship which he had held since 1898 in the Collège de France. Although the conditions in the Collège favored research, this school granted no diplomas and consequently, with the exception of a few courses in literature, etc., attended by society folks, the lecture rooms remained almost empty and Le Chatelier was happy when he had a half dozen listeners. At the Sorbonne his audience numbered three hundred or more and the preparation and perfection of his lectures consumed much of his time. He also was kept busy by the research students, a dozen or so, who worked under his direction and consequently he found it necessary to give up his personal laboratory work. He might have increased his output of research by drafting these young men into service, a practice that is widespread and eminently respectable, but he altruistically gave them his time and advice, and not once did his name appear on the papers put out by his students, even when he in reality was the principal author. This sacrifice made him beloved by his students who appreciated both his fair play and the consequent advantage they gained when seeking positions. The output from his laboratory exceeded in number and importance that from any of the science departments of the Sorbonne, and the gain in his reputation as a teacher more than compensated him for what he may have lost as a scientist.

Le Chatelier as editor of the *Revue de Metallurgie* was preparing a series of articles on high-speed steels and was struck by the statement that Taylor had discovered these remarkable materials by accident. Having little faith in pure chance, he wrote a pointed comment on the real significance of chance in science, emphasizing that chance observations are of little value unless they lead to well-planned investigations. This brought him a letter from Taylor who told him that the discovery of these steels was in reality the fruit of an intensive systematic study extending over two years. He also sent Le Chatelier a pamphlet outlining the methods by which he had attacked industrial problems, and the latter was delighted to find here examples of the application of the scientific method which might well serve as a model to even professional scientists. The essential features of Taylor's procedure were (1) change one variable at a time, (2) make precise measurements of each single factor, (3) define exactly the objective of each step. He sought Le Chatelier's aid in his projected crusade to spread the general doctrine of the scientific management of work, an invitation that was gladly accepted. Le Chatelier's translations of Taylor's books had a wide sale, and his own writings and addresses did so much to further this effort to bring about a closer union of science and industry, that Le Chatelier was not only made honorary chairman of the first international congress on scientific management (Paris, 1929), but he was awarded its first gold medal. However, despite the acclaim with

which these efforts were greeted by the industrialists of France, little real progress has resulted. Le Chatelier ascribes this failure to the fact that most of the studies, made in the name of efficiency engineering, are empirical and not scientific, a condition for which he holds the current engineering curricula responsible. Too much factual knowledge and insistence on memory exercises cannot be expected to produce a graduate possessing a real appreciation of the scientific method. Consequently much that the industries have called scientific management is really rationalization.

War Activities

At the outbreak of the war, Le Chatelier, though not liable for military duty because of his age, offered his services to the government. He was assigned to visit the munition factories and to transmit to the Minister of War any suggestions he might offer for the improvement of this branch of the service. He was given no authority to order changes, but was to act merely as an expert advisor. This commission afforded him opportunity to study numerous problems which he solved in characteristic fashion. He was astounded to discover how many details of factory practice had never been really investigated, a condition that was prevalent in even large well-organized plants with technical staffs available. Reliance on local tradition and confidence in the reputed skill of workmen often resulted in inefficiency and inferior products. Taylor's dictum that a systematic study, no matter how costly, of all the steps in a manufacturing process would lead to eventual economy, had become Le Chatelier's guiding principle and he applied this method of approach with gratifying results.

A newly created steel plant was delivering projectile stock that produced an undue number of rejects. The difficulty was traced to the refractory used in lining the casting ladles. It was too friable, spalled off, and formed inclusions in the ingots. Le Chatelier was asked to find a remedy and as he had no special knowledge of this subject he asked the larger and older steel makers for the requisite information. He found that none of the technical men knew the precise specifications of a good lining, and that the choice was left either to the foremen and workmen or to the purchasing agents, who also had no definite knowledge of what they were using or buying. Le Chatelier then took a refractory that had been found satisfactory, determined its content of clay binder, its grain size, the mechanical strength of the mix—wet, dry, and after burning—and finally the porosity. From these data he was able to write a working formula for producing a mixture whose properties were identical with those of the satisfactory specimen.

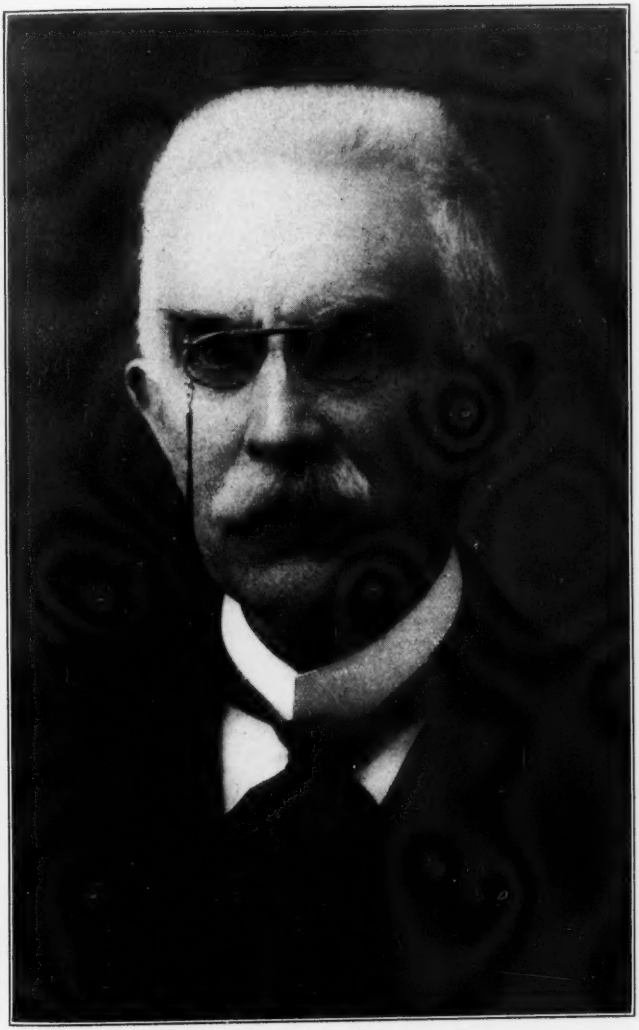
He studied the tempering of projectiles, devised a simple, yet reliable method of controlling this process, and by the end of the war at least half of the projectiles produced in France were tempered in accordance with

his suggestions. While investigating the preparation of ammonium nitrate from Norwegian calcium nitrate and ammonium sulfate, he observed that when the reaction was carried out at 100°, well-crystallized $2CaSO_4 \cdot H_2O$ resulted. This could be easily washed with boiling water as it hydrates very slowly at this temperature. He therefore recommended that boiling water be used when making plaster of Paris mortar since less water may be used and the set mass is then much harder. He made a complete study of the manufacture of silica bricks. The resistance to compression of refractories was measured at high temperatures, alumina and magnesia failed at about 1300°, while silica did not lose its mechanical strength below 1600°. This excellence is due to a network of crystalline tridymite formed during the burning of the bricks. Due to a difference in solubility, the quartz which is unstable above 800°, in the presence of a small quantity of flux, is transformed into tridymite stable up to 1450°.

At this period, Claude was trying to develop the industrial synthesis of ammonia. He was guided to a large extent by the computations made by Le Chatelier, who had in fact taken out a patent long before Nernst and Haber had made their experiments. Claude's efforts met with complete failure and he came for criticism and advice to Le Chatelier. The latter made certain suggestions and Claude then, for the first time, had the pleasure of seeing liquid ammonia issuing from his apparatus.

Gun platforms, the reconstruction of bridges, and fortifications required an ample supply of high-strength, rapid-setting cements. Le Chatelier, as an expert in this field, was asked by the government to make recommendations, which were followed to the letter. He advised that certain manufacturers be asked to grind their mixes finer and increase the lime content of their products and he also recommended the large-scale production of calcium aluminate cements, which though known for a long time had never been made industrially. The results were eminently satisfactory and a large output of these cements has been maintained for they are excellent for many industrial purposes.

Le Chatelier, during the early part of the war, visited Sir Robert Hadfield, the English metallurgist, who told him of his experiments on the use of manganese steel for trench helmets. Le Chatelier tested this material and found it twice as resistant to penetration as the steel used in the French helmets. He made the logical recommendations and was told that the French had nothing to learn from the English. When the Americans arrived in France, they heard of these studies, and requested Le Chatelier to give them his data. He thus had the satisfaction of contributing in some measure to the adoption of manganese steel for the American helmets. The French also followed this lead but not until ten years after the close of the war.



HENRY LOUIS LE CHATELIER—1930

M. AND MME. LE CHATELIER AT THE POLYTECHNIC SCHOOL OF COPENHAGEN
Le Chatelier was invited there to deliver a series of lectures before the Society of Sciences of Denmark, 1923.

Retirement

When hostilities ceased Le Chatelier decided to give up gradually his official positions. He was still in full vigor, even though he was now seventy, but he felt it would be better to retire rather than to wait until the infirmities of old age would make his offices a burden. However, his life had always been full of incessant activity and retirement for him could never mean a cessation of endeavor. Though he left his academic teaching duties, he continued his educational work in the larger sense. As leader in progressive movements, he gives much time and effort to the causes which he believes worthwhile, bringing always to the world the fruits of his wide experience and matured philosophy. He writes and speaks much on educational reform, Taylorism, the closer coördination of pure and applied science, the factors leading to success in scientific work, the relation of science to economics, etc. His consulting services are valued by large corporations producing cement, glass, steel, synthetic ammonia, etc.—fields in which he is an acknowledged authority.

He never writes or speaks merely to amuse; he is constantly striving to produce a reaction. He has often declared: "I am not an intellectual and knowledge interests me only in so far as it leads to action," and yet he

REUNION IN THE LIBRARY OF THE LABORATORY AFTER MR. LAFUMA'S DEFENCE OF HIS THESIS, 1925

Those seated, from left to right, are Lafuma, Le Chatelier, and Guichard, the last being professor of analytical chemistry at the Sorbonne and director of the laboratory of the mint.

The balance on the extreme right is that constructed by Deleiul for St. Claire Deville and used for the weighing of the standard platinum meter.

heartily recommends a classical training as the best preliminary to a scientific training. Though justly proud of his successes, he is personally the kindliest of men, simple, unassuming, easy to meet, and always anxious to help those who ask his aid. Young scientists seeking a reasonably sure approach to success can do no better than to study his life and deeds; an emulation of this great man would be an ideal noble enough for any one.

Sulfur Found Good for Alkali Soils. Sulfur must take its place on the list of approved fertilizers minerals, at least for certain types of land. Such is the indication of experiments performed by Prof. W. L. Powers of the Oregon Agricultural Experiment Station, reported at the Second International Soil Science Congress held in Leningrad.

Prof. Powers has attacked the problem of black alkali, one of the most hopeless types of land ruin in the arid and irrigated West. He found that applications of sulfur, especially when used in combination with a nitrogen-rich organic fertilizer, will reclaim such land and make it yield good crops.

Even normal land is often benefited by sulfur application, he found. Sulfur-treated fields produced higher yields of alfalfa, which had a richer, greener growth than that of the unsulfured fields.—*Science Service*

FERTILIZER FROM THE AIR. A PROJECT FOR CHEMISTRY STUDENTS AT THE SECONDARY-SCHOOL LEVEL

HOWARD R. WILLIAMS, WESTERN RESERVE ACADEMY, HUDSON, OHIO

Nitrogen and oxygen from the air were caused to unite to form nitrogen dioxide under the influence of an electric arc between copper points in a plaster of Paris combustion chamber. The spark was obtained from a model "T" Ford spark coil energized by storage batteries. The resulting gases were drawn through distilled water which formed nitric acid by reaction with the nitrogen dioxide.

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO.$$

The acid was then neutralized with calcium carbonate to form calcium nitrate fertilizer. The fertilizer thus made was fed to growing corn in a pot in the school laboratory, beside which another pot of corn without fertilizer was grown. The growth difference in one month was quite marked and proved the efficacy of the fertilizer made.

. . . . . .

The youths of pragmatic America are becoming pragmatists. They are rapidly developing the questioning mind. Very probably, this attitude is noticed at its greatest intensity and at its best by the teaching profession of America. Time and again the teacher is confronted by the question, expressed by word or attitude, "Of what practical importance is all this to me?"

This is as it should be. The curriculum content, be it chemistry, English, mathematics, or whatnot, has very little if any justification unless it contributes to the happiness and welfare of the student either at the present time or in the fairly immediate future. The ingenuity of the teacher is sometimes taxed to the limit to find practical and worthwhile applications for the subject matter of the curriculum.

A few years of chemistry teaching is enough to impress any one that the theory of chemistry needs illumination by numerous examples of practical uses. This is usually done in a didactic way and by a field trip or two to some chemical manufactory when possible. It seems, to the writer, that while this is all good, it is not quite adequate. Therefore, for the past several years, we have been developing a practical laboratory method for vivifying elementary chemistry at Western Reserve Academy. The procedure used in this work has been outlined rather fully in two previous articles in this journal (*1*). It is sufficient to state here that the procedure is an adaptation of the project method of teaching in which actual industrial processes are duplicated in miniature in the school laboratory; the work being done by the student with a minimum of assistance and advice from the instructor.

The manufacture of atmospheric nitrogen into nitrates by the Birkeland-Eyde process furnishes a project that is at once intensely interesting,

instructive, and important. The importance of the process is growing as the natural deposits of nitrates disappear, so that the appeal of the project to the student is enhanced by the feeling that he is working upon a problem that is some day going to be the means of keeping human life from perishing from the earth.

Upon first thought it might seem that the project would be much beyond the possibilities of the equipment on hand or obtainable in a high-school laboratory. However, we believe we have simplified the apparatus so that the project is well within the reach of any high-school chemical laboratory. At least just a little borrowing from the physics department or from friends will make it possible to obtain all the necessary apparatus.

The requisite parts of the apparatus are as follows: (1) a combustion chamber in which the nitrogen and oxygen of the air are burned to oxides of nitrogen, (2) a source of electrical energy of from six to twelve volts, (3) an induction coil for transforming the original low-voltage current into a current of high enough potential to form a fairly generous continuous spark or arc, (4) an absorption chamber where the nitrogen oxides may be converted into nitric acid, and (5) a suction apparatus that will keep the air and gases moving in a continuous stream through the apparatus.

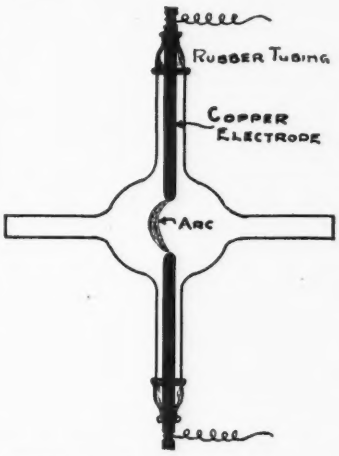


FIGURE 1.—GLASS BULB WITH FOUR SIDE TUBES

The first thing we constructed was the combustion chamber or furnace. Our first furnace was made of glass, so that we might closely observe everything that took place. The glass blowing required in the construction of the furnace was done by the instructor. All the rest of the project was carried on by the student. A glass bulb with four side tubes was blown as shown in Figure 1. Two opposite side arms were larger in diameter to receive the copper electrodes or arc points. The other pair of opposite side arms were smaller in diameter as they carried the air current into and out of the combustion chamber. The main body of the furnace was a bulb about one and one-half inches in length and about one and one-quarter inches in diameter. The side arms were about two and one-quarter inches in length, giving the entire assembly a diameter of about six inches. It is not at all necessary to follow these dimensions in reproducing the work, but we found the furnace of this size to give excellent results.

While we found the glass chamber excellent for clear vision, the high temperature to which it was subjected caused it to crack. If pyrex glass were used it would, of course, obviate this difficulty. However, lacking the pyrex glass, we made an exactly similar furnace from molded plaster of Paris with side arms of glass tubing set into the plaster and a glass window on the top of the furnace for purposes of observation.

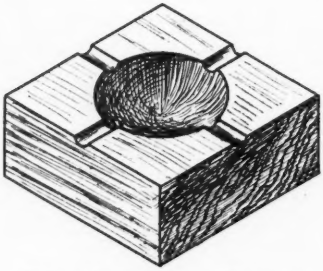


FIGURE 2.—MOLD FOR FURNACE

The mold for the plaster of Paris furnace was made from a block of white pine about four inches square and one and one-half inches thick. In the center of this block we gouged a hemispherical hollow two inches in diameter and one inch deep. Next semi-cylindrical grooves were cut for the glass tubing inserts for the electrodes and air inlet and outlet as described above. The construction of the mold is shown in Figure 2. The mold was then thoroughly greased with vaseline to keep the plaster of Paris from adhering as it set. Enough thin plaster was then mixed and poured into the mold to fill it about two-thirds full. It was then squeezed out with the thumb to fill the mold and side grooves and leave a hollow depression in the center which was to be the inside of the furnace. While the plaster was yet soft, the glass tubes to be used as side arms were pressed into the grooves to about half their diameters so as to leave their imprints. After the plaster had thoroughly hardened the cast was shaken out of the mold and the same process used to make a second cast for the other half of the furnace.

Before assembling the furnace, a square hole was cut in the upper half as shown in Figure 3. A piece of window glass was set into this hole and plastered around the edges. This was the window through which the spark could be watched in adjusting the electrodes and spark coil points. The furnace was then ready for assembling. The glass tubes were cemented into place and the two halves of the furnace were cemented together (Figure 4). Thin plaster of Paris was used as the cement.

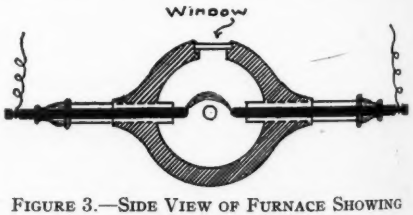


FIGURE 3.—SIDE VIEW OF FURNACE SHOWING OPENING CUT FOR WINDOW

The copper electrodes or arc points were made from two pieces of heavy copper wire, about one-eighth inch in diameter, and four inches long. The inside or arc ends of these electrodes were ground so as to be roughly hemi-

spherical in shape. A groove was filed in the outer ends to facilitate the attachment of the wires from the spark coil. A piece of small rubber tubing about three-quarters of an inch long was slipped over the ends of the glass side tubes of the furnace and the copper electrodes passed through them. The rubber tubing kept air from entering the chamber through the tubes carrying the electrodes, and at the same time gave enough friction on the copper electrodes to hold them steadily at the right spark distance and to allow of easy adjustment.

A continuous spark or arc was used inside the furnace to cause the nitrogen and oxygen of the air to unite. This spark was obtained from an ordinary model "T" Ford spark coil. Any other induction coil of like capacity would do fully as well. The difficulty of attaching wires to the terminals of the Ford spark coil was overcome by mak-

FIGURE 4.—CONSTRUCTION OF THE PLASTER OF PARIS FURNACE
On the left is the wooden mold. In the center is a cast (half a furnace) made from the mold. On the right is the completed furnace.

ing a wooden frame in which to set the coil and placing binding posts and spring brass strips in this frame so that they would make contact with the coil terminals as shown in Figure 5. Ordinary stove bolts and nuts were used as binding posts.

The source of electric energy for the spark coil may be governed by available supply. It just so happened that we have a small motor-generator set which delivers A. C. to D. C. at a potential of twelve volts. We have also operated this acid plant on two six-volt storage batteries with complete success. A six-volt current such as is obtained from one storage battery or from a model "T" Ford generator will also furnish energy enough to make the apparatus successful. The twelve-volt source, making the spark larger and more efficient, cuts down the time of operation for obtaining an acid of given strength.

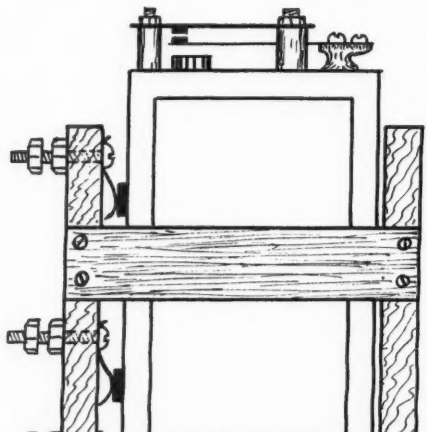


FIGURE 5.—SHOWING METHOD OF ATTACHING WIRES TO THE TERMINALS OF THE FORD SPARK COIL

We next assembled the apparatus as shown in Figures 6 and 7. Air was drawn through the apparatus by means of an aspirator or filter pump placed at the end. The air was drawn first through a calcium chloride tube to remove water vapor and dust. Next it entered the combustion chamber where it came into contact with the spark. Here a part of the nitrogen was caused to combine with oxygen under the intense heat of the spark. The following reactions (*2*) represent what probably takes place:

$$N_2 + O_2 \longrightarrow 2NO.$$

As the nitrogen monoxide is drawn away from the spark, and as it cools, it unites with more oxygen,

$$2NO + O_2 \longrightarrow 2NO_2.$$

The nitrogen dioxide thus formed was drawn through about ten cubic centimeters of distilled water in the test tube absorption chamber as shown in Figure 6. Here the nitrogen dioxide united with the water to form nitric acid and nitrogen monoxide,

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO.$$

The nitric acid remained in the water in the absorber and the nitrogen monoxide by-product was probably drawn on through the apparatus and lost.

During the operation of the apparatus, with the glass combustion chamber described above, the brown color of nitrogen dioxide was plainly visible in this chamber, clearly showing the course of the reaction in that part of the plant.

We placed a trap bottle, as shown, between the absorber and the aspirator. During the operation of the plant, a small but perceptible vacuum is maintained throughout the apparatus. When it became necessary to shut the plant down, to clean or adjust the spark coil points or for any other reason, the vacuum caused water to be suddenly sucked from the aspirator back into the apparatus. The trap bottle caught such water on the back-kick and prevented it from entering and fouling the acid in the absorbing chamber.

We occasionally stopped the process to test the acid in the absorber. After a run of one-half hour the acid in the absorber was of sufficient concentration to change blue litmus to red. After a few hours of running the acid was so strong that a drop of it on

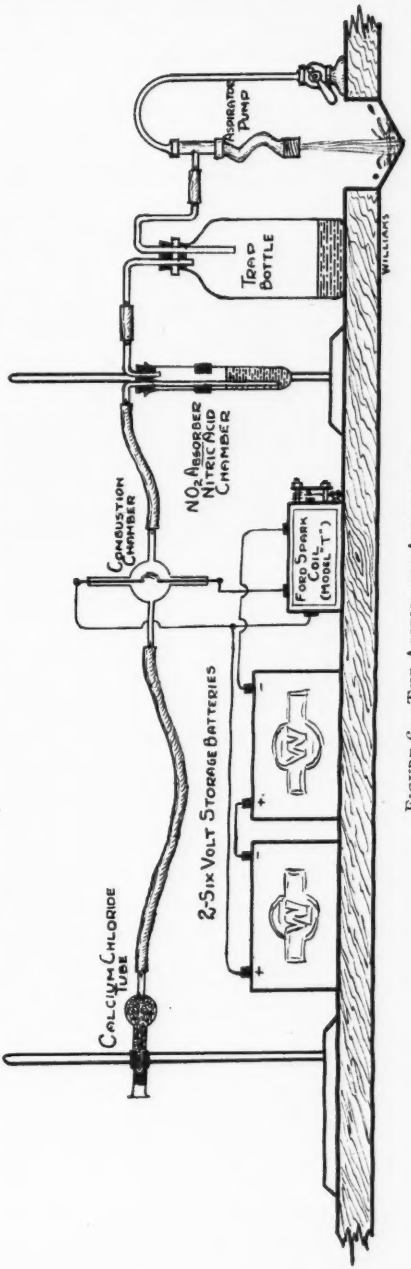


FIGURE 6.—THE ASSEMBLED APPARATUS

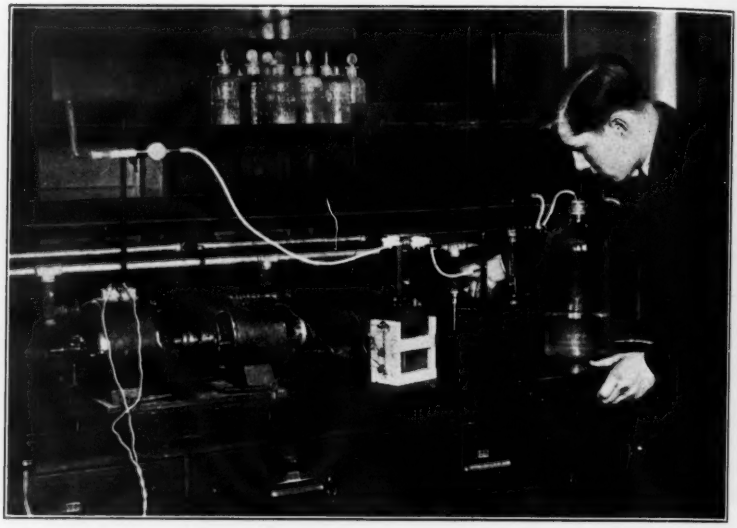


FIGURE 7.—GIVEN BREWER AND THE MODEL BIRKELAND-EYDE NITRIC ACID PLANT WHICH HE BUILT

the tongue tasted quite sour and set the teeth "on edge." All told we operated the plant for twelve hours.

The acid taken from the apparatus was next neutralized by the addition of a slight excess of finely precipitated calcium carbonate. We prepared this by treating a strong solution of calcium chloride with a solution of sodium carbonate. Some finely ground limestone would do just as well.

We next evaporated the calcium nitrate to dryness and weighed it. The twelve hours run gave us 0.4732 gram of calcium nitrate. This was equivalent to 0.3058 gram of nitric acid or very close to a three per cent solution. Although the commercial Birkeland-Eyde plant yields nearly a 50 per cent solution, we were quite pleased with our modest results. Our pleasure was further heightened by the whiteness of our finished product which indicated high purity.

The calcium nitrate thus formed was the fertilizer which we had started out to make. We wished, however, to go one step farther and test the usefulness and efficacy of the fertilizer we had made. Accordingly, we obtained two small tins cans which we transformed into flower pots by punching holes in their bottoms. We filled the cans with some rather mediocre soil, of which we have a great abundance in our immediate neighborhood.

We next ran a test for acidity on the soil we were using. We placed about five cubic centimeters of the soil in a test tube and then filled it about

two-thirds full of freshly prepared blue litmus solution. Upon thorough shaking and subsequent settling, we found the litmus solution to have turned pink. We therefore added about one-quarter teaspoonful of dry calcium hydroxide (lime) to the soil in each can to correct the soil acidity shown by this test.

In the soil in each can, we then planted three grains of corn (maize) obtained gratis from a local feed store. Pot No. 1 we kept watered with pure distilled water, to make sure that the young plants received nothing except what they got from the soil. Pot No. 2 we watered with distilled water into which we put our calcium nitrate. We placed our entire output of 0.4732 gram of calcium nitrate into twenty-five cubic centimeters of water. This we fed to the plants in pot No. 2 at the rate of fifteen drops a day, five to each plant. This was not so much fertilizer as is usually given by a farmer to his field corn, but was sufficient to make the growth difference shown in the photograph in Figure 8. Calculations from data gathered showed that the average farm application is equivalent to about twenty grams of nitrate per hill of four or five stalks, or about five grams per stalk.

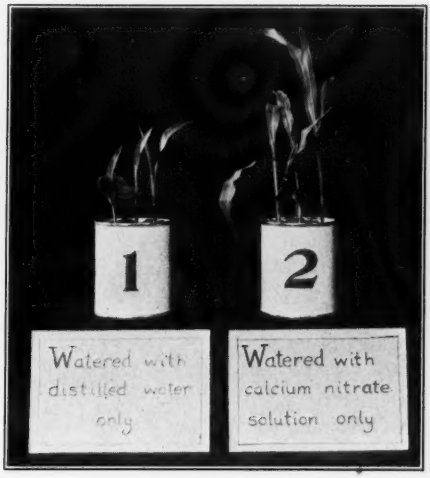


FIGURE 8.—EFFECT OF CALCIUM NITRATE UPON CORN
The seed had been planted just four weeks the day this photograph was taken.

After the completion of the project, we recapitulated by analyzing the project for educational objectives. We found that the project went into the fields of biology and physics as well as chemistry and likewise into the field of English when the project was written up and orally reported to the class. However, confining ourselves to the field of science, we found the project to require a knowledge of at least the following objectives:

1. To transform a low-voltage direct current into a high-voltage current.
2. To learn about combustion at high temperatures.
3. To write chemical reactions.
4. To absorb a gas in water.
5. To build chemical apparatus.
6. To make a salt from an acid and a carbonate (making calcium nitrate from nitric acid and calcium carbonate).

7. To use calcium chloride as a drying agent.
8. To use plaster of Paris and learn why it "sets."
9. To attach batteries in series so as to get the sum of their voltages and the amperage of one, rather than the sum of their amperages.
10. To use a nitrate fertilizer.
11. To calculate the amount of fertilizer to use on a given amount of seed.
12. To learn how the growth of a plant depends upon fixed nitrogen.
13. To make an acid from a non-metallic oxide and water.
14. To calculate the equivalent amount of nitric acid formed from the weight of calcium nitrate obtained.
15. To make a carbonate by metathesis (making the calcium carbonate from calcium chloride and sodium carbonate).

Literature Cited

(1) WILLIAMS, "A Working Model By-Product Coke Plant. A Chemistry Project for a Student at the Secondary Level," J. CHEM. EDUC., **6**, 745–52 (Apr., 1929); "From Corn to Karo," *ibid.*, **7**, 1147–53 (May, 1930).

(2) The reactions given are taken from MCPHERSON and HENDERSON, "A Course in General Chemistry," Ginn & Co., Boston, Mass., **1915.**

Ozone Preserves Color of Red Peppers. When is a red pepper not a red pepper? When it is faded, of course. The Basic Science Research Laboratory of the University of Cincinnati has discovered that if red peppers are kept in a dark and damp place, and given daily doses of ozone, they will not bleach. In the past there has been considerable loss due to the bleaching of the color from red peppers while they were in storage.

Shortly after the beginning of the investigation, the scientists found that the red pigment that colors the peppers was sensitive to the effects of light. The stronger the light, the more rapidly the color bleached. Not long after this, they found that peppers kept carefully dry, bleached more quickly than the others. The remedy then seemed obvious—store them in a dark, damp chamber. But every one knows what happens when food is kept in a damp place. It molds. They found that several varieties of the common aspergillis mold grew on the damp red peppers. Now a number of chemicals will readily prevent the formation of these molds, but most of them are either unsuitable for use on foods, or else they bleach the red peppers in the presence of moisture.

At last ozone was tried, and it was found to be successful. It killed the mold without bleaching the red peppers, although earlier experiments with ozone had indicated that it would bleach them if they were dry. Perhaps the most surprising thing of all is the small quantity of ozone actually required. One-tenth of one per cent for a period of ten minutes a day is enough to preserve the ruddy appearance of the peppers.

Apparently the bleaching of the red peppers occurs when the skin of the peppers dries out and cracks. Then the air and light reach the delicate inner tissues of the peppers where the red pigment is stored, and bleach them. Thus it is actually the darkness and moisture that prevent the bleaching of the color in the peppers, while the ozone merely serves to stop the mold from growing on them.—*Science Service*

DEVELOPMENT OF PHARMACEUTICAL CHEMISTRY IN MARYLAND*

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The history of the development of pharmaceutical chemistry in Maryland is traced in more or less chronological sequence during the past century and a half. The ways in which the retail pharmacies, the School of Pharmacy, the drug industries, and certain of the chemical industries have contributed to Maryland's present position in pharmaceutical chemistry are briefly summarized.

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The present state of development of pharmaceutical chemistry in Maryland can rightfully be said to be of the highest order and this enviable position has not been attained through the manufacture of a large variety of pharmaceutical chemicals, nor through the production of some few in very large quantities. It is rather to be attributed to the pioneer work done in the production of inorganic chemicals; the development of analytical methods and their application to the standardization of drugs and chemicals; to the painstaking research which has been carried out in connection with the discovery of certain organic compounds of great merit medicinally, and to the development of methods for their production on a commercial scale.

As is true of the development of other fields of chemistry, the present state of progress can neither be attributed to the accomplishments of a few, nor was it brought about in a short period of time. It represents the composite labors of many over a period of more than a century and its history is closely interwoven with the development of retail pharmacy in the state, the School of Pharmacy, the drug industries, and certain of the chemical industries which in their infancy catered to the drug trade.

Drug stores made their appearance in Maryland long before the advent of any establishments for the manufacture of chemicals. The available records show that there were quite a number of druggists doing business in the state prior to 1764. These druggists handled, in addition to vegetable drugs, certain crude chemicals, some of which required purification before they were fit for medicinal use. While it is true that the processes used for purification were simple, consisting in the main of solution, filtration, and recrystallization, yet these simple operations were carried out by pharmacists and must be looked upon as the beginning of pharmaceutical chemistry in this locality. Furthermore, these early drug stores must be credited with having been the laboratories in which some of the early

* Editor's Note: This paper was written at the request of the editor as part of a survey of the chemical industries, resources, and education of Maryland. For various reasons it has seemed advisable to abandon the idea of compiling individual state surveys. Nevertheless, it is felt that this paper will be of interest to many of our readers; hence it is presented herewith.

founders of domestic chemical industries received their practical education.

It is not until the early part of the nineteenth century that there is any record of the manufacture of pharmaceutical chemicals in Maryland. In 1812, Richard Caton, Esq., and others began the manufacture of copperas and alum on the Magothy River. In 1816, Messrs. Howard Sims and Isaac Tyson, Jr., erected a laboratory on Pratt Street for manufacturing "chemical paints" and "medicinal chemicals," which they later transferred to Washington Avenue. The manufacturing done by these plants, however, was limited to the production of a few crude chemicals in a small way, and it was not until some years later that the industry assumed noteworthy proportions.

The Maryland Chemical Works, established in 1826, was the first local plant of its kind to undertake the production of chemicals on an extended scale. Among the more important pharmaceutical chemicals, which they manufactured in 1827, were Epsom salt, alum, vitriolated tartar and soda, blue vitriol, aqua fortis, red precipitate, salt of tartar, carbonate of soda, carbonate of magnesia, calcined magnesia, tartar emetic, Rochelle salts, calomel, and sulfuric acid. At about this time, there was also organized the Baltimore Chemical Company which made a similar line of chemicals and which also catered principally to supplying the druggists' needs.

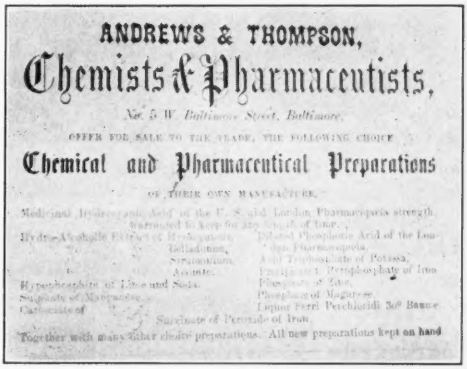
It would appear that even in this early period of development Maryland had more than a local reputation for the manufacture of pharmaceutical chemicals. Samuel F. Troth, a Philadelphia druggist, in a paper read at a meeting of the Philadelphia College of Pharmacy in 1864, and printed in the *American Journal of Pharmacy* in 1874, stated that, in 1821, the firm of which he was a member purchased their Epsom salt from London and continued to do so until the Baltimore manufacturers put a stop to the practice.

Up until the middle of the nineteenth century chemicals were handled almost exclusively by druggists. They dealt, not only in chemicals used for medicinal purposes, but in paint pigments, chemicals used in tanning, fertilizer chemicals, *et cetera*. And the first chemical manufacturing plants established in Maryland endeavored to supply all of these materials. The pioneer work done by these establishments must, therefore, be looked upon as a step in the progress of pharmaceutical chemistry in the state. While it is true that but a vestige of these early activities remains so far as the manufacture of inorganic pharmaceutical chemicals is concerned, nevertheless they must be recorded as one of the achievements in this field of chemistry.

As medical and pharmaceutical science progressed, demands for chemicals of greater purity and for certain special chemicals used exclusively in medicine were created. These demands the pharmacists themselves

attempted to meet and in some cases they were met by chemists who had a pharmaceutical training.

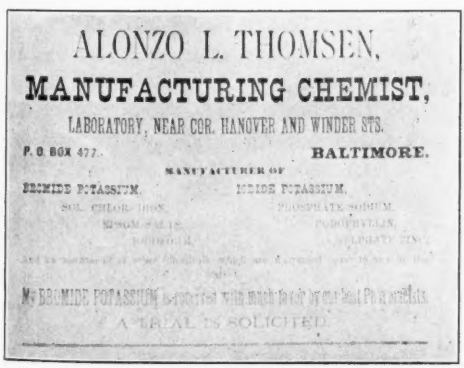
The drug firm of Andrews and Thompson, established in 1853, at one time manufactured hydrocyanic acid for the pharmacists in Baltimore. They also made such chemicals as gold chloride, silver nitrate, and calcium hypophosphite.


ANDREWS & THOMPSON,
Chemists & Pharmaceutists,
No. 5 W. Baltimore Street, Baltimore,
OFFER FOR SALE TO THE TRADE, THE FOLLOWING CHOICE
Chemical and Pharmaceutical Preparations
OF THEIR OWN MANUFACTURE.
Together with many other choice preparations. All new preparations kept on hand

AD APPEARING ON PAGE 6 OF THE *Journal and Transactions of the Maryland College of Pharmacy* FOR 1859–60

In 1882, Alonzo L. Thomsen, one of the sons of J. J. Thomsen, who was a member of the drug firm of Thomsen and Block, opened a laboratory for the manufacture of pharmaceutical chemicals at the corner of Hanover and Winder Streets. He served his apprenticeship in pharmacy with his father and then attended the University of Heidelberg where he specialized in the study of chemistry. For many years he manufactured for the drug trade potassium bromide, potassium iodide, solution of chloride of iron, Epsom salt, phosphate of sodium, zinc sulfate, iodoform, also ammonium chloride, bismuth subnitrate, resublimed iodine, and sulfuric, nitric, and hydrochloric acids.

About this same time, in 1880, there was begun in Baltimore the manufacture of "prepared chalk," which, at that period, was used exclusively in the making of certain pharmaceutical preparations. This industry was begun in a small way by George W. Thomas, grew to considerable size, and still flourishes today.

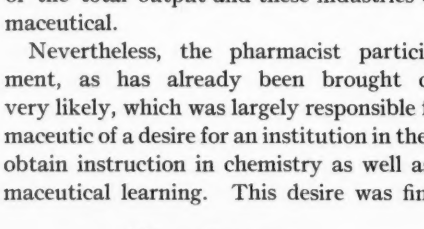

ALONZO L. THOMSEN,
MANUFACTURING CHEMIST,
LABORATORY, NEAR COR. HANOVER AND WINDER STS.
P. O. BOX 477. BALTIMORE.
MANUFACTURER OF
BROMIDE POTASSIUM. IODIDE POTASSIUM.
A TRIAL IS SOLICITED.

AD APPEARING ON PAGE 26 OF THE "ANNUAL ANNOUNCEMENT OF THE MARYLAND COLLEGE OF PHARMACY, SESSION OF 1883–84"

As new industries using inorganic chemicals sprang up in this country, new avenues of distribution for these products

were established and the production of these chemicals primarily for the drug trade gradually diminished until at the present time there are no manufacturers of these chemicals in Maryland catering primarily to the druggists. It is true that certain inorganic chemicals widely used by pharmacists, such as the mineral acids and potassium dichromate, are still manufactured in the state, but the drug trade takes only a small portion of the total output and these industries can no longer be classed as pharmaceutical.

Nevertheless, the pharmacist participated in their early development, as has already been brought out, and it is this connection, very likely, which was largely responsible for the creation in the body pharmaceutic of a desire for an institution in the state where its apprentices might obtain instruction in chemistry as well as in the other branches of pharmaceutical learning. This desire was finally translated into action and, as a result, there was established the Maryland College of Pharmacy, which became a department of the state university in 1920, and is now known as the School of Pharmacy of the University of Maryland.



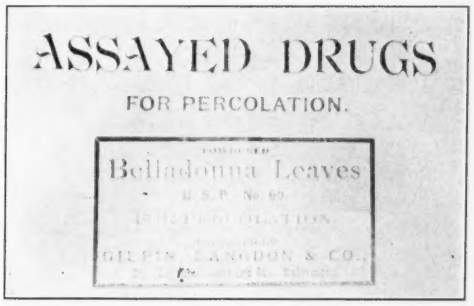
MARYLAND COLLEGE OF PHARMACY, AISQUITH NEAR FAYETTE STREET, BALTIMORE, MARYLAND
Occupied 1877–86.

The Maryland College of Pharmacy, the fourth oldest school of pharmacy in the United States, was incorporated in Baltimore in 1841, and has, almost from its very beginning, exercised a marked influence on the development of local pharmaceutical chemistry. The chair of chemistry, which was one of the three first established, has been occupied during the life of the school by several exceptionally able men, who were not only good investigators, but also good teachers. Among them were such outstanding characters as Dr. William E. A. Aiken, Dr. Louis Steiner, Dr. William Simon, Dr. Daniel Base, and to this list must be added Dr. Charles C. Caspari, Jr., who occupied the chair of pharmacy at one time. These men, without exception, were indefatigable workers and were of the type that is able to imbue students with the master's spirit. To them must be given credit, in a large measure, for the progress which pharmaceutical chemistry has made in the state since 1850.

The School of Pharmacy has contributed to the development of pharmaceutical chemistry in Maryland in a number of ways. Its faculty has been active in the development and improvement of teaching methods,

e. g., the school was the first of the pharmacy schools in this country to introduce laboratory work as a requirement in the course in chemistry. The "Manual of Chemistry," written by Professor Simon, is additional evidence of the school's activity in this field. That the book, first published in 1884, has been a worthwhile contribution is indicated by the fact that it is now passing through its thirteenth edition.

The chemistry and pharmacy departments of the school have done a considerable amount of creditable research, some of which has been creative, but most of which has been in the field of applied chemistry, having had for its object the development or improvement of assay methods for the standardization of drugs and their preparations. In the early days, work of this nature was done by Professors Israel J. Grahame and J. Faris Moore, both of whom attained national reputations. Their work was followed by that of such able and well-known investigators as Professors Caspari, Simon, and Base, and in more recent times by that of Dr. John C. Krantz, Jr.


ASSAYED DRUGS

FOR PERCOLATION.

Belladonna Leaves

U. S. P. No. 69

PERCOLATION

GILPIN, LANGDON & CO.

AD APPEARING ON THE BACK OF PAGE 37 OF THE "ANNUAL CATALOGUE OF THE MARYLAND COLLEGE OF PHARMACY, SESSION OF 1889–90"

The most outstanding piece of research of this nature, and one which has received international recognition, was done by Professor Charles C. Caspari, Jr., of the department of pharmacy, working in conjunction with Dr. Alfred Dohme, a member of the firm of Sharp and Dohme. It consisted of the development of volumetric methods for the assay of certain alkaloid-containing drugs. The work, the first of the kind carried out in this country, was done so well and the methods developed proved to be so satisfactory that they were introduced into the United States Pharmacopœia of 1900, this being the first time that this type of assay was recognized by any of the national pharmacopœias. In this connection, it should also be stated that it was a Maryland firm, Gilpin, Langdon and Company of Baltimore, that first introduced to the trade assayed drugs for percolation. These were placed upon the market for the first time in 1889 and they immediately found ready purchasers.

For many years the school has taken an active part in the revision of the two official drug standards of the country, the United States Pharmacopœia and the National Formulary. Professors Charles C. Caspari, Jr., and E. F. Kelly served as members of the committees appointed to

revise these standards in 1910 and at least one other member of the faculty at that time, Dr. John C. Krantz, Jr., rendered valuable assistance in the revision of the chemistry of the Pharmacopœia. These works are now undergoing another revision and two of the present faculty are members of the committees of revision. Dr. A. G. DuMez is a member of the Committee of Revision of the Unites States Pharmacopœia, and chairman of the Sub-Committee on Nomenclature. Dr. Glenn L. Jenkins is a member of the Committee of Revision of the National Formulary, and chairman of the Sub-Committee having the revision of the chemistry of that work in charge.

The most important contribution which the school has made in this field of endeavor, however, and the one which has had the greatest influence on the development of pharmaceutical chemistry within the state consists of the training which it has given its students and the inspiration which has come to them as a result thereof. The present system of drug control in the state and the influence for good which it has had is due largely to the organizing ability and wise direction which it received under Professor Charles C. Caspari, Jr., a graduate of the school and the dean thereof for a number of years. The high state of development of the pharmaceutical manufacturing plants of the nationally known firms of Sharp & Dohme, and of Hynson, Westcott, and Dunning are due largely to the vision of their founders, all of whom were graduates of the school. Furthermore, much of the research work in pharmaceutical chemistry carried on in the laboratories of the school, in those of the manufacturing plants and in those controlled by the state, has been and still is the work of graduates of the school.

The system of drug control now in force in the state has had a good influence on the morale of the body pharmaceutic, is largely responsible for the high standards of quality maintained for the drugs and pharmaceutical preparations sold in the state; and the officers who are reponsible for the operation of its chemical laboratories have contributed their share to the advancement of pharmaceutical chemistry within the state. Some idea of the nature and development of this work may be gained from the following brief resumé.

The State Pure Food and Drug Law, which created the chemical laboratories for the examination of food stuffs and drugs, was passed in 1910. Professor Charles C. Caspari, Jr., then dean of the School of Pharmacy, was appointed the first state food and drug commissioner. He was succeeded by Dr. Fred C. Blanck in 1918 and the latter by Dr. A. L. Sullivan, who is the present incumbent of the office. In 1922, the work of the bureau was divided and Dr. R. L. Swain was made deputy food and drug commissioner in charge of drug work. The first chief of the chemical laboratory was Dr. W. B. D. Penniman, who was succeeded in 1916 by

Dr. Wyatt Randall, and the latter in November, 1930, by Dr. John C. Krantz, Jr., the present incumbent of the office. In addition to the chief there are four other chemists employed in the laboratory.

The duties of this bureau are to enforce the food and drug standards prescribed by the laws of the state. To accomplish this there is a corps of food and drug inspectors who collect samples throughout the state and submit them to the laboratory where their quality is tested. Up to the present time, more than 12,000 samples of these products have been analyzed. In addition to this routine work, a considerable amount of research, with special reference to the improvement of assay methods, has been carried out. As an example of work of this kind which lies in the field of pharmaceutical chemistry may be mentioned the development of a method by Penniman and Randall for the determination of volatile oils in extracts, of a modified method for the assay of zinc oxide ointment, of a distillation method for the determination of chloroform in chloroform liniment.

FIRST PLANT OF SHARP AND DOHME

At the present time the manufacture of pharmaceutical chemicals in Maryland is practically limited to the two firms already mentioned; namely, Sharp & Dohme, and Hynson, Westcott, and Dunning, both of which are located in Baltimore. As the growth of this industry over a period of more than half a century is represented almost wholly by the activities of these firms, it is believed that the development in this field can best be pictured for the reader by sketching briefly the organization and growth of these two establishments.

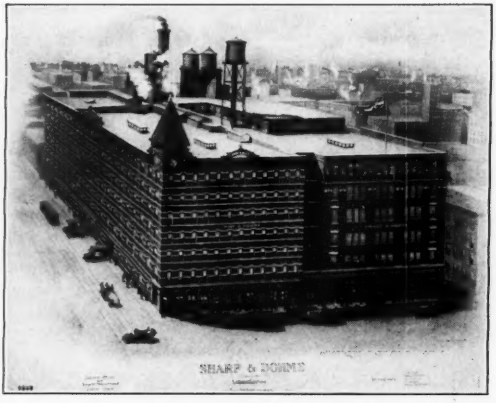
The firm of Sharp & Dohme was organized in 1860 by Alpheus P. Sharp, Louis Dohme, and Charles E. Dohme. Mr. Sharp was a member of the first graduating class of the Maryland College of Pharmacy (1842), and the other two were members of the classes of 1855 and 1860, respectively.

They first undertook the manufacture of galenical preparations and did not enter the field of chemical manufacturing until 1886, when they began the production of pure plant principles, such as podophyllin and aloin. In 1900, they began the manufacture of alkaloids, the work being directed by a French chemist, Charles Serre, but this venture was dis-

continued in 1904. At the present time the purely chemical manufacturing of the firm consists of the production of hexylresorcinol and dihydranol.

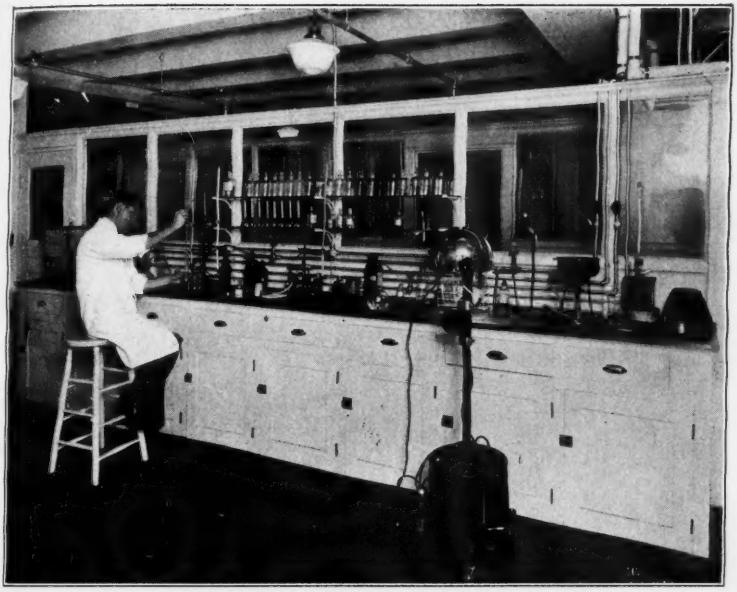
In 1891, Dr. Alfred R. L. Dohme, the son of Charles E. Dohme, was taken into the firm. Dr. Dohme was educated as a chemist and at that time had just returned from a two-year sojourn in Europe where he studied under A. W. Hoffman, Fresenius, Flückiger, and other well-known chemists. With his advent, a number of changes in the conduct of the plant was made. A thorough system of analytical control of all products including the assay of all potent drugs was inaugurated and research along chemical lines was begun. For a time the research and control departments were conducted as one, but in 1927, they were separated and a number of new members were added to the research staff.

The business of the company has grown from year to year, necessitating several enlargements of the plant. Only recently a new addition was built and several of the older departments were modernized. In 1929 the company acquired and has since absorbed the H. K. Mulford Company and thus has become the owner of one of the leading producers of biological products in this country and a large producer of very pure and efficient insulin. The plant is now one of the largest of its kind in the country and is thoroughly modern in every respect. At the present time the firm employs over eight hundred people exclusive of the office force; six of these are engaged in chemical and pharmacological research, three are employed in analytical control work, and the remainder carry out the various manufacturing operations.



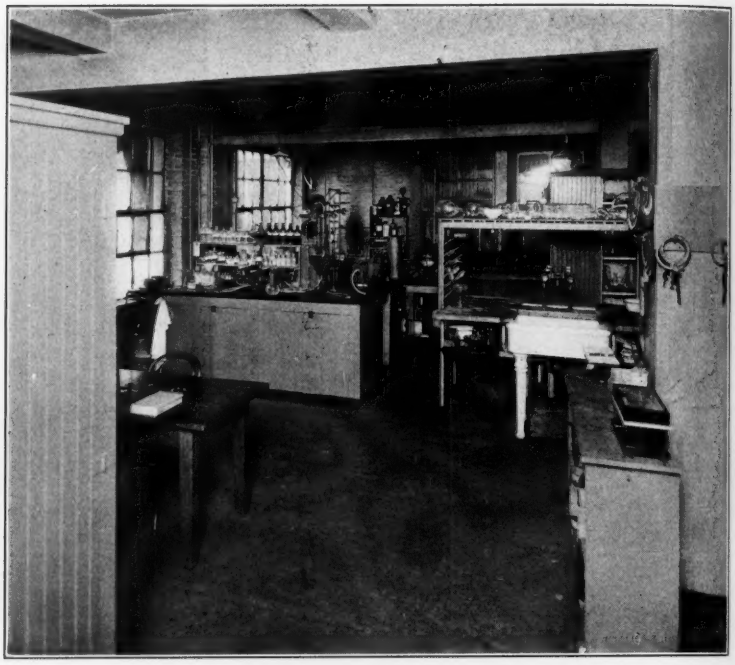
SHARP & DOHME LABORATORIES IN BALTIMORE, 1915

Among the products produced by its research laboratories should be mentioned ergotole, a concentrated preparation of ergot, especially for hypodermic use; hexylresorcinol, one of a series of about fourteen alkyl resorcinols synthesized by Dr. Alfred R. L. Dohme and his staff in 1923 and found to possess valuable germicidal properties; dihydranol(2,4-dihydroxyphenyl *n*-heptane), a compound which destroys the fermentation organisms of the intestinal tract and which it is said can be taken without harm or danger to the patient.



Laboratory of Pharmaceutical Research.

Biochemical Assay Laboratory.
LABORATORIES OF SHARP & DOHME, BALTIMORE, MARYLAND

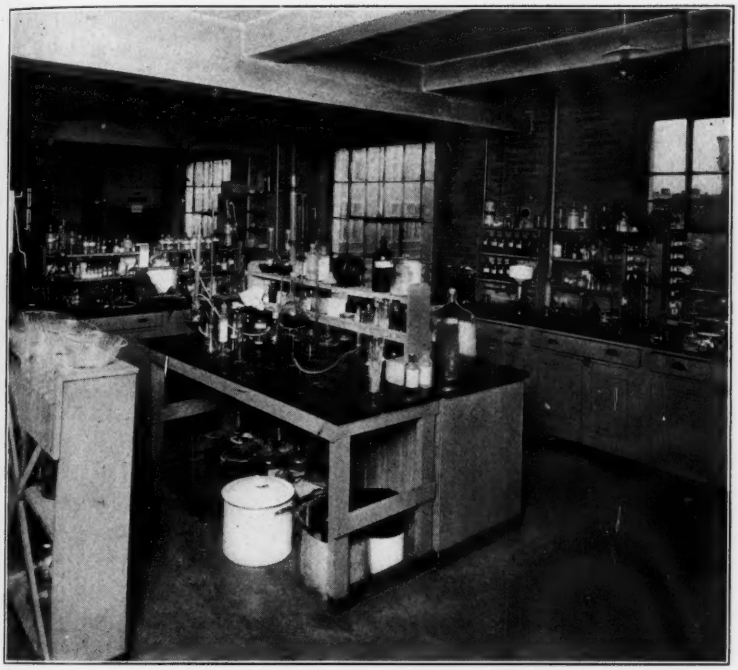


CHEMICAL LABORATORY, HYNSON, WESTCOTT, AND DUNNING, INC.

Throughout the seventy-five years of its existence, the firm has conducted an ethical business and has established an enviable reputation for its products based largely upon their good quality and reliability. Its research and control staffs have made many valuable contributions to pharmacy and chemistry, and, with this staff, enlarged as it is at present, an ever-increasing number of contributions may be expected in the future.

The firm now known as Hynson, Westcott, and Dunning was organized in 1889 by Messrs. Henry P. Hynson and James W. Westcott, both of whom were graduates of the Maryland College of Pharmacy. In 1894, Mr. H. A. B. Dunning, who is also a graduate of the Maryland College of Pharmacy, entered the employ of the firm, was taken in as a member some years later and is now its president.

The business was first operated as a type of retail pharmacy in which the scientific and professional side of the calling were emphasized. The venture was entirely successful and in 1899, the firm was conducting a strictly ethical retail business in which there were about forty people employed. The first work of a strictly chemical nature was undertaken in 1910, when



CHEMICAL LABORATORY, HYNSON, WESTCOTT, AND DUNNING, INC.

Drs. Rowntree and Geraghty sought Mr. Dunning's coöperation in the distribution of the phenolsulfonephthalein test solution used by them in the estimation of kidney function.

The process used at that time for the preparation of phenolsulfonephthalein was long and tedious and unsuited for manufacturing on a commercial scale. After extensive research Mr. Dunning perfected two commercial processes for the production of pure sulfonephthalein in large quantities. The solution of this problem more than any other factor was probably responsible for the firm entering into the field of chemical manufacture. Later the manufacture of corpus luteum products was begun in a small way. Production, however, was stepped up rapidly to meet the constantly growing demand for these products until approximately 50,000 pounds of hog ovary glands are now being used annually.

Numerous other chemical procedures have since been developed by Mr. Dunning, among them being a method for the production of urease of a high degree of purity for use in the determination of urea in urine and blood, and processes for the manufacture of the sulfonephthaleins,

other than phenolsulfonephthalein; such as tetrabromphenolsulfonephthalein, thymolsulfonephthalein, bromthymolsulfonephthalein, cresosulfonephthalein, and dibrom-cresosulfonephthalein. Mr. Dunning also coöperated in producing mercurochrome (dibromoxymercurifluorescein), the forerunner of which was dimercuriphenolsulfonephthalein, and was the first to prepare the water-soluble product, the two per cent solution of which has since become popular as a general antiseptic.

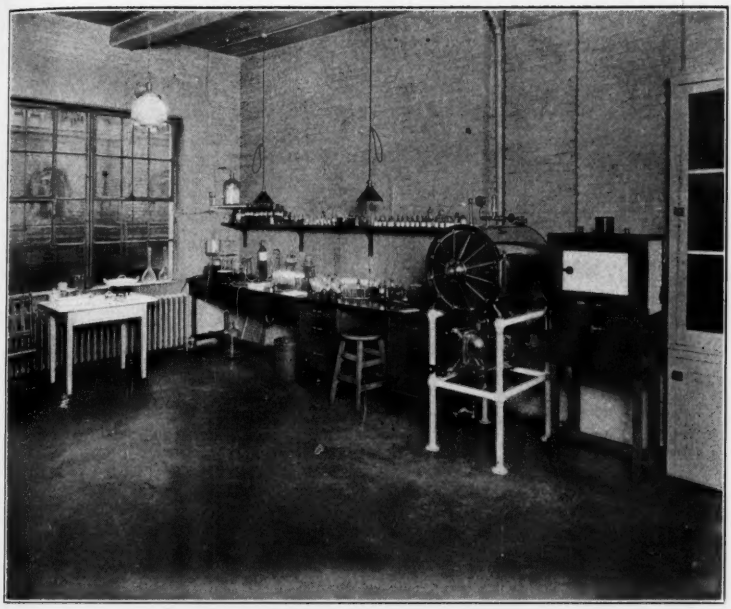
At the present time, it is a general business policy of the firm to offer coöperative service to medical investigators, and as a result of such cooperation several otherwise unobtainable products for use in experimental and clinical medicine have been prepared. Important among such products is heparin, the blood anticoagulant, first discovered by Dr. W. H. Howell of The Johns Hopkins School of Hygiene.

Mr. Dunning is a firm believer in the value of scientific investigation and an efficient research staff is maintained. The chemical research staff is as follows: Dr. E. E. Reid, professor of organic chemistry, The Johns Hopkins University, consultant and director of research; Fitzgerald Dunning, Ph.D., active director of chemical research; W. C. Harden, M.S.; A. E. Stickels, A.B.; M. F. Barr; and G. Spurrier. The equally important pharmacological and bacteriological staffs are headed respectively by David I. Macht, M.D. (formerly assistant professor of pharmacology, The Johns Hopkins University), and W. Eric Drake (formerly of the University of Bristol). Practically the entire time of this staff is devoted to pure research, scientific investigation being the prime consideration. The development of the application of the results obtained is considered to be of secondary importance. Studies are now being made of antiseptics, local anesthetics, biologicals, and diagnostic agents.

RETAIL PHARMACY AND LABORATORIES OF HYNSON, WESTCOTT, AND DUNNING

A unique feature of this establishment is that there is still operated in connection therewith a retail pharmacy which is said to be the finest in the United States from the standpoint of appointments and management.

Both of the above-mentioned plants have contributed much to the advancement of pharmaceutical chemistry within the state by way of discovery of new compounds, the development of processes for their production on a commercial scale and the contributions to chemical research made by members of their staffs. For many years chemical work of the highest order has been done in these establishments and it is chiefly due



Bacteriological Laboratory.

Pharmacological Laboratory.

LABORATORIES OF HYNSON, WESTCOTT, AND DUNNING, INC., BALTIMORE, MARYLAND

SCHOOL OF PHARMACY, UNIVERSITY OF MARYLAND, DEDICATED MAY 10, 1930

to the effort exerted in their development rather than to any other cause that Maryland occupies a front rank in this field of service today.

In this brief survey, the attempt has been made to picture in more or less chronological sequence the conditions in pharmaceutical chemistry in Maryland as they developed in the past and as they are at present. It is believed that the picture shows that those engaged in this line of endeavor in the state have kept pace with the times and that the progress made here compares favorably with that in any of the other states, or with that in other fields of chemistry. With the increased interest in research shown by our pharmaceutical manufacturing plants in recent years, and the excellent quarters and facilities for doing advanced work and research in the chemical and biological sciences which the School of Pharmacy now has in the new building erected by the state in 1930, the outlook for future progress appears to be exceptionally bright.

Green fruit brings no profit to the grower; it damages the health of the eater; it is particularly bad for the young who are not able to distinguish between ripe and unripe.—KEKULÉ

CHEMICAL INDUSTRIES AND THE RAW MATERIALS IN MARYLAND*

EDWARD B. MATHEWS,† THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MARYLAND

The mineral resources of Maryland are summarized and the influence of their occurrence in the state on the location of the early chemical industries in the United States is indicated.

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The chemical industries in Maryland now have little connection with the natural resources or mineral deposits of the state though their location in Maryland, particularly in the vicinity of Baltimore, is largely due to the low-grade deposits which could be utilized to advantage in the early days of the Province before the richer deposits in various parts of the United States were discovered.

In general the mineral resources of the state conform to the long recognized three-fold division of the physiography and geological formations, viz., the Coastal Plain, the Piedmont Plateau, and the Appalachian Region. In the coastal plain portion of the state which includes all that part of the state lying southeast of the Baltimore and Ohio and Pennsylvania railroads running from Wilmington to Washington, the deposits consist of clays, sands, and gravels which form the raw materials for the extensive ceramic establishments centered about Baltimore. The quality of these clays is that of those found along the greater part of the eastern coast of the United States from New England southward and has been the basis of common brick and terra cotta manufacture, with occasional plants for the better grade of porcelain ware. In the coastal plain deposits is also found the diatomaceous earth, which is composed of the microscopic hard parts of diatoms, which have been worked from time to time in the manufacture of absorbents and heat-retaining coverings. Its use as a Fuller's earth has never been successfully developed as the low refractoriness of these gelatinous micro-organisms has prevented the development of any manufacture of refractory ware.

In the Piedmont area, which extends westward from the coastal plain to the Blue Ridge, are a series of highly crystalline ancient rocks composed of old sediments and great masses of intrusive granites and gabbros with occasional lava flows from volcanoes active before the time of organic life in this region. It is in this area that all of the chrome, copper, magnesia, and a large part of the iron occur which has occasioned localization of

* *Editor's Note:* This paper was written at the request of the editor as part of a survey of the chemical industries, resources, and education of Maryland. For various reasons it has seemed advisable to abandon the idea of compiling individual state surveys. Nevertheless, it is felt that this paper will be of interest to many of our readers; hence it is presented herewith.

† State Geologist.

chemical industries in Baltimore. Probably the most interesting products, from the chemical standpoint, are associated with the small areas of serpentine such as are found at the Bare Hills, Soldier's Delight, and in a line across Harford County to the Pennsylvania line in northern Cecil County. It was in these serpentines that the chrome and magnesium carbonate were found which were the occasion for the development of the Baltimore Chrome Works and some of the pharmaceutical laboratories in Baltimore city.

About a century ago Dr. H. H. Hayden recognized that some of the white veins in the serpentine were composed of the magnesium carbonate and from this material there began a small manufacture of Epsom salt for medicinal purposes. These veinlets were never very large or particularly pure but served to start the manufacture of pharmaceutical compounds which are now entirely derived from raw materials brought into Baltimore from all parts of the world. The discovery of the value and utilization of the black component of the serpentine, known as chromite, is an interesting illustration of the keen observation and utilization of a young man who applied his casually acquired knowledge at the opportune moment. According to the story, Philip Tyson, who had traveled abroad and had visited chrome works in Glasgow, noticed that the hogsheads brought into the Baltimore market by a farmer were held in place by black rocks which appeared similar to the raw material used in the manufacture of chromium salts in Glasgow. Young Tyson sought out the source of these black masses and found that they had come from the serpentine areas above mentioned. He examined the ground, found the deposits as well as many others of similar character in the serpentine barrens of the state, secured title to these apparently worthless lands, and undertook the manufacture of chromium salts from this material. From this small beginning was developed a large family fortune and the establishment of the Baltimore Chrome Works where, it is interesting to note, the first industrial chemist was employed. It was not long before richer deposits of chromite were found in other parts of the world which have been the source of most of the raw material refined in the Baltimore Chrome Works and it was soon realized that the lean deposits found in Maryland could not be worked profitably in competition with the richer deposits found in the Far East. Attempts have been made from time to time to operate these local deposits of chromite but never with success except under peculiar conditions. Even during the recent war when the receipt of chromite was shut off and the price rose to an abnormal figure, it was found practically impossible to secure an appreciable amount of the raw material at a profit. Occasional washings of chrome sands in a small way by individuals are, however, still carried on in Cecil County and probably also in the Baltimore County serpentine area.

In the same area of the Piedmont are found the few copper deposits of the state which in the old days were found to be sufficiently rich to warrant exploitation and to furnish a source of some of the material which was refined in the Baltimore Copper Works. It has been frequently stated that the copper deposits of the Bare Hills north of Baltimore, in the vicinity of Sykesville, and in Frederick County, were the occasion for the establishment of the Baltimore Copper Works but it seems more probable that this establishment relied upon raw materials from South America and later from the western states. Prior to the establishment of the Baltimore Copper Works, copper was refined and rolled in a small way in connection with the iron furnaces, the copper coming from outside the state. When the much purer and richer deposits of copper were found in the Lake Superior region and later in the well-known copper camps of the far west we realized that the lean, hard ores of the Maryland occurrences could not be worked profitably. Attempts have been made from time to time to open the old mines at Liberty or at New London and also at Bare Hills but the conditions are not favorable for successful development of the copper industry based upon these raw materials. Now most of the old workings are marked only by dumps which serve as a hunting ground for mineral collectors.

The manufacture of iron in Maryland was once an active industry with furnaces, forges, and rolling mills at many points along the southern edge of the Piedmont where the carbonate ores of the coastal plain could be worked by means of the water power of the Piedmont. The fact that it was possible to secure the raw materials for iron in Maryland was early recognized and the industry of exporting iron to England had come into being by 1718. About this time Washington's father and half-brother became interested in the industry and their company soon outranked all others in America in the manufacture of pig and bar iron. While most of the earlier furnaces were near tidewater, the manufacture of iron had commenced in Frederick County prior to the Revolution but the works in the neighborhood of Cumberland were not developed until a century later.

The substitution of steel for the higher grades of iron in many forms, the discovery of extensive deposits of rich ores in other sections of our country, particularly in Michigan, Minnesota, and the southern states, coupled with the wonderful extension and cheapening of transportation, have resulted, within the past few years, in such improvements in the methods of producing iron and steel and in cheapening their cost, as have driven out the charcoal furnace and bloomery, and, under the principle of the survival of the fittest have left no place for the lean ores of Maryland and the antiquated methods of other days.

The present era of iron manufacture in Maryland with the extensive works along the shores of the Baltimore harbor is based upon a new prin-

ciple, viz., the location of plants on the seaboard where the rich ores from foreign lands may be brought to be worked by coal from the nearby coal fields. In the perfection of sites for this combination Sparrows Point is unsurpassed. Raw ores from all parts of the world may be delivered directly to its works while coal may be secured under competitive conditions by rail or water delivery and the distribution of its finished product has a similar transportation advantage. The daily production of a single modern steel plant may easily exceed the total annual production of the many forges and furnaces of the early days.

The manufacture of cement represents a chemical industry based upon raw materials drawn from the Piedmont area and from the Appalachians to the westward. Originally limestones were selected of a composition which approximated that of portland cement and the so-called natural cement works at Cumberland and Hancock, where they secured desirable rock from nearby ledges, long maintained an enviable reputation. At the present time the larger cement works, like those at Hagerstown and Union Bridge, do not trust to varying composition of the natural rock but produce their products by the careful mixture of the various ingredients selected from scattered points, the variations of chemical composition being controlled by numerous analyses. The modern cement plants are expensive and the operators cannot afford to produce other than uniform high-grade products of cement and hydrated lime.

Materials of less importance found in the Piedmont area which enter into the chemical industries include quartz and feldspar. These minerals occur in the form of pegmatite dikes which are so coarse-grained that the individual minerals may be separated by hand cobbing into a form ready for use in the ceramic industry. A little of the material is used in the state but most of it is sent either to the large pottery works of New Jersey or to East Liverpool, Ohio. Pegmatite dikes of this character are found widely scattered in the crystalline rocks of the world and become of economic importance only when it is possible to secure the individual constituents in great purity. They occur most abundantly in the valley of the Patapsco River and at various points in Harford and Cecil counties. Some of them carry the potassium feldspar orthoclase; others the sodium feldspar albite. The ratio of the feldspar to the quartz is not constant but tends to approach the eutectic mixture of seventy-two per cent feldspar and twenty-eight per cent quartz. When the grain becomes too small to separate the quartz from the feldspar and particularly the small flakes of mica and other constituents carrying iron which would color the porcelain ware, these deposits become worthless.

In the western part of the state beyond Cumberland are the great deposits of high-grade coal which occur in a series of strata, some of them like the "Big Vein" of unusual size and purity. Because of their quality

they are not used directly in the chemical industries but become a chief source of power. The coal area of Maryland has an extent of approximately four hundred fifty-five square miles and the original supply, before erosion or mining, has been estimated as over eight billion tons. The annual production is about four million tons and the total exhaustion something over eight million tons, leaving the greater portion of the original supply still in the ground.

Beneath the coal occurs a stratum of highly refractory fire clay which has been the basis of an extensive industry in the manufacture of enameled brick. The high-grade fire clay is used for the manufacture of the high-class brick, and on it is flowed an enamel mixture of fire clay and fusible constituents which may be melted into glass without fusion of the brick itself. The compounding of a glaze which will have shrinkage value the same as that of the underlying brick during cooling is one of the most delicate chemical processes carried on among the chemical industries in Maryland.

The foregoing discussion of the chemical industries of the state shows that while the raw materials of Maryland at the present time are but little used, their occurrence in the state during the period of infancy of the chemical industries in the United States exercised a powerful influence in determining the location of these chemical works. It is also interesting to recall that it was the chrome industry in Maryland which led to the first regular employment of a chemical engineer in the United States.

War Gases Tested as Medical Weapons. Mustard gas, dreaded weapon of the World War, has been reported as possibly preventing and curing a number of diseases. The latest peacetime development of this gas is the announcement by the British Empire cancer campaign that it may prevent cancer in areas of the skin which have been painted with tars that ordinarily produce cancers. This does not in any way mean that mustard gas will cure cancer. Even its preventive action is extremely limited. But recent investigations may lead to a more general preventive method, it is said.

The starting point for the experiments leading to this discovery may have been the reported British observation that none of the British soldiers who were exposed to mustard gas in the war ever developed cancer, it has been suggested. German experiments along similar lines have also been reported.

Previously mustard gas had been heralded as a cure for locomotor ataxia, and other war gases were tried as cures for colds, tuberculosis, and various respiratory diseases.

Mustard gas is a sulfur compound, dichlordiethyl sulfide. Recently a Philadelphia scientist, Dr. Frederick S. Hammett, suggested that control of cancer might be gained by means of another sort of sulfur compound. He did not claim to have found any cure for the disease. However, he did state that transplantable tumorous growths in mice had been made to diminish and in at least one case to disappear altogether by the application of an organic compound containing partially oxidized sulfur.—*Science Service*

THE ACTION OF BASES ON NON-METALS

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Most of the non-metallic elements, with the exceptions of nitrogen and the rare gases, react with the alkali hydroxides. In general the reactions take place in accordance with the type

$$Cl_2 + 2NaOH \longrightarrow NaCl + NaOCl + H_2O.$$

Compounds in which the non-metallic element is respectively negative and positive, or the decomposition products of the same, are formed. The exact mechanism of this type of reaction is not known and is not discussed. The reaction with carbon is anomalous. Further evidence is obtained by the reactions with the alkali amides, which are analogous to the hydroxides in the ammonia system of compounds. In ammonia, the polysulfides, polyphosphides, etc., are more stable than in water, but the ammono salts are less stable than the corresponding aquo salts.

. . . . . .

Reactions are known to take place between bases and many of the elements. These elements may be divided into two classes—the metals at the left of the periodic table, and the non-metals. Most of the intermediate elements are not very readily attacked.

The purpose of this paper is to discuss the action of bases upon the non-metallic elements, most of which react with bases, with the exceptions chiefly of the Group 0 gases and nitrogen. Some of these reactions are used commercially, as for example the production of bleaching powder and of lime-sulfur spray by the action of chlorine and sulfur, respectively, on calcium hydroxide. At first sight, it seems as though these various reactions have no close relation to each other. However, it has been shown that these reactions can generally be referred to a certain type (*1*), namely,

$$Cl_2 + 2NaOH \longrightarrow NaCl + NaOCl + H_2O,$$

in which one atom of chlorine gains an electron and is converted into the negative chloride ion Cl^-, and the other loses an electron and goes into the hypochlorite ion ClO^-, in which the chlorine has a positive valence of one. The hypochlorite ion may be pictured as analogous to the hydroxide ion OH^-, in which positive hydrogen is replaced by positive chlorine.

There are two general conditions under which these reactions may take place, the first being the use of solutions of the bases, and the second the use of the fused bases. In the case of a given element, these two conditions may give quite different reaction products, but closer study reveals the fact that these variations are probably due chiefly to the difference in temperature and concentration. Reactions in aqueous solutions of bases take place at temperatures up to a few degrees above 100°C., whereas sodium hydroxide melts at 318°C. and potassium hydroxide at 360°C., and the reactions of the fused substances usually take place in the vicinity

of, or above, the melting point. The difference in the two types of reactions may be explained, in part at least, as being due to the instability of some of the initially formed products at the higher temperature of the fusion process.

The mechanism of this type of reaction is not well known. It will suffice here to point out that the course of the reaction usually results in the formation of one compound in which the non-metal is negative, and another in which it is positive (as in NaCl and NaOCl in the first equation), or the decomposition products of the same.

The usual reaction of chlorine and sodium hydroxide is given in the first equation. When chlorine is passed into a hot solution of sodium hydroxide, some sodium chlorate is formed by a reaction of auto-oxidation and reduction

$$3NaClO \longrightarrow NaClO_3 + 2NaCl$$

and similarly, when a solution of sodium chlorate is heated, auto-oxidation and reduction again occurs.

$$4NaClO_3 \longrightarrow 3NaClO_4 + NaCl$$

Bromine and iodine react with alkalies in a similar manner to chlorine. Fluorine, however, has a different reaction.

$$2F_2 + 4NaOH \longrightarrow 4NaF + 2H_2O + O_2$$

This apparent anomaly can be brought into line by assuming the formation of the hypofluorite, which breaks down immediately into the fluoride and oxygen.

$$2NaOF \longrightarrow 2NaF + O_2$$

Indeed, hypochlorous acid is known to break down on heating with the evolution of oxygen.

$$2HOCl \longrightarrow 2HCl + O_2$$

Further evidence for the intermediate formation of the hypofluorite is the discovery of oxygen difluoride (*2*), OF_2, which has been separated from the gases evolved from the action of fluorine upon a two per cent solution of sodium hydroxide. This oxide may be considered as the anhydride of the hypothetical hypofluorous acid.

In group six we find that sulfur, selenium, and tellurium react with sodium hydroxide in a similar manner. In the case of sulfur the reaction may be summarized in this equation,

$$(2x + 2)S + 6NaOH \longrightarrow 2Na_2S_x + Na_2S_2O_3 + 3H_2O$$

The reaction takes place with the primary formation of the sulfide and sulfite, which then add on sulfur to form, respectively, the polysulfide and thiosulfate.

$$3S + 6NaOH \longrightarrow Na_2SO_3 + 2Na_2S + 3H_2O$$
$$Na_2SO_3 + S \longrightarrow Na_2S_2O_3$$
$$Na_2S + (2x - 2)s \longrightarrow 2Na_2S_x$$

The reaction differs in the case of selenium and tellurium in the non-formation of the thioselenate and thiotellurate from the selenite and tellurite.

$$(2x + 1)Se + 6NaOH \longrightarrow 2Na_2Se_x + Na_2SeO_3 + 3H_2O$$

The equation representing the reaction of phosphorus and sodium hydroxide is usually written:

$$4P + 3NaOH + 3H_2O \longrightarrow PH_3 + 3NaH_2PO_2$$

The reaction is more complicated than represented by this equation (*3*). The following equations probably express the reaction better, although not accounting for all of the products formed.

$$4P + 10NaOH \longrightarrow 2Na_3P + 2Na_2HPO_3 + 4H_2O$$
$$2Na_3P + 7H_2O \longrightarrow PH_3 + NaH_2PO_2 + NaOH + 2H_2$$

Combining these equations:

$$4P + 10NaOH + 3H_2O \longrightarrow PH_3 + 2Na_2HPO_3 + NaH_2PO_2$$

The presence of the higher oxidation product has been shown, as well as the presence of higher hydrides of phosphorus. The first equation postulates the initial formation of the phosphide, in which phosphorus is negative, and the phosphite in which it is positive, the phosphide then hydrolyzing in a more complex manner than would be supposed from the simple equation

$$Na_3P + 3H_2O \longrightarrow 3NaOH + PH_3$$

When arsenic is boiled with a solution of sodium hydroxide, arsine and an alkali arsenite are formed.

$$As + 3NaOH \longrightarrow AsH_3 + Na_3AsO_3$$

The arsine probably results from the sodium arsenide which might be expected to form first. When arsenic is fused with sodium hydroxide, sodium arsenide, sodium arsenite, and hydrogen are formed. The following equations express the reactions.

$$2As + 6NaOH \longrightarrow Na_3AsO_3 + Na_3As + 3H_2O$$
$$Na_3As + 3H_2O \longrightarrow 3NaOH + AsH_3$$
$$2AsH_3 \longrightarrow 2As + 3H_2$$

Some sodium arsenide would be expected to remain as the water would be driven out immediately. These two reactions of arsenic differ chiefly in the temperature at which they take place, the arsine being decomposed at the higher temperature.

The reaction with carbon, although much studied, is not very well defined. Sodium has been prepared by reduction of the hydroxide with

carbon. Sodium carbonate, carbon monoxide, hydrogen, hydrocarbons, and various complex compounds have been reported in reactions of various forms of carbon with the hydroxides. It seems as though the reaction is not definite enough to attempt to bring it in line with the others.

Silicon, germanium, and tin all react similarly with the bases.

$$M + 4KOH \longrightarrow K_4MO_4 + 2H_2$$

M represents the various elements. The ortho compounds are not stable and consequently the meta salts of the type K_2MO_3 are obtained.

In Group III, boron reacts with sodium hydroxide to form sodium orthoborate and hydrogen.

$$2B + 6NaOH \longrightarrow 3Na_3BO_3 + 3H_2$$

The evolution of hydrogen is probably similar to the cases of silicon, germanium, and tin.

Further evidence that the non-metals in general react with bases in accordance with the equation

$$Cl_2 + 2NaOH \longrightarrow NaCl + NaOCl + H_2O$$

is advanced by a study of the reactions of the non-metals on the alkali amides, which are the strong bases of the ammonia system of compounds. The alkali amides are thus the analogs of the alkali hydroxides (*4*). Ammonia resembles water closely in many of its abnormal properties, *i. e.*, boiling point, heat of vaporization, surface tension, the property of dissolving salts to form conducting solutions, etc. Sodium hydroxide may be considered as derived from water by replacing a hydrogen by a sodium atom. In fact, this is one method of preparing sodium hydroxide. In an analogous manner, sodium amide may be derived from ammonia by replacing a hydrogen by a sodium atom. This reaction also takes place, but the velocity is much less than the previous one.

$$2Na + 2HOH \longrightarrow NaOH + H_2$$
$$2Na + 2HNH_2 \longrightarrow NaNH_2 + H_2$$

The following reactions show the similarity between these two types of compounds.

$$Ba(NO_3)_2 + 2KOH \longrightarrow Ba(OH)_2 + 2KNO_3$$
$$Ba(NO_3)_2 + 2KNH_2 \longrightarrow Ba(NH_2)_2 + 2KNO_3 \ (5)$$

In water, barium hydroxide is precipitated if the solutions are not too dilute. In ammonia, barium amide, the analogous compound, is precipitated.

$$2Al + 2KOH + 4H_2O \longrightarrow KOAl(OH)_2 + 3H_2$$
$$2Al + 2KNH_2 + 4NH_3 \longrightarrow KNHAl(NH_2)_2 + 3H_2 \ (6)$$

Aluminum dissolves in potassium hydroxide solution to form potassium aluminate. In potassium amide solution, potassium ammonoaluminate is formed.

$$2C_6H_5CHO + KOH \longrightarrow C_6H_5CH_2OH + C_6H_5COOK$$
$$2C_6H_5CH{=}NH + KNH_2 \longrightarrow C_6H_5CH_2NH_2 + C_6H_5C(NH)NHK \ (7)$$

Benzal imine, the ammono analog of benzaldehyde, undergoes the Cannizzaro reaction with potassium amide, benzylamine, an ammono alcohol, and potassium benzamidine, the salt of an ammono acid, being formed.

$$C_6H_5SO_2ONa + NaOH \longrightarrow C_6H_5OH + Na_2SO_3$$
$$C_6H_5SO_2ONa + NaNH_2 \longrightarrow C_6H_5NH_2 + Na_2SO_3 \ (8)$$

The sodium salt of benzene sulfonic acid when fused with sodium hydroxide forms phenol; when it is fused with sodium amide, aniline, the ammono analog, is formed. These reactions serve to show the similarity in the reactions of the alkali hydroxides and amides.

The reactions of the non-metals with potassium amide are in general similar to those of potassium hydroxide. There are two chief differences in the reactions. One is the increased stability of homo-atomic anions, *i. e.*, polyphosphides, polysulfides, polystannides, etc., in liquid ammonia (*9*), since ammonolysis does not take place to the extent that hydrolysis goes on in water. The other is that salts of ammono acids, such as the ammonohypochlorites, are not as stable as the corresponding aquo salts, the hypochlorites. This instability is characteristic of many compounds of nitrogen, such as the nitrides, a number of which are quite explosive.

The reaction between the halogens and potassium amide in liquid ammonia or boiling toluene is as follows, where X_2 represents the halogen.

$$3X_2 + 6NaNH_2 \longrightarrow 6NaX + N_2 + 4NH_3 \ (10)$$

This reaction is quite similar to the reaction of fluorine on sodium hydroxide since the ammonohypohalites are unstable. In each case, the halide, the solvent, and the negative element of the solvent are formed.

Hydrogen reacts with sodium amide at 300° as follows:

$$H_2 + NaNH_2 \rightleftharpoons NaH + NH_3 \ (11)$$

Pure sodium hydride has not been prepared by this method. This reaction takes place in the preparation of sodium amide from sodium and ammonia when the reaction is stopped before all of the sodium has reacted. It is probably fundamentally different from the other reactions, but is similar in that sodium hydride and ammonia are formed, in which compounds hydrogen is respectively negative and positive.

Sulfur, selenium, and tellurium react with sodium amide in liquid ammonia (*12*) to form respectively polysulfides, polyselenides, and polytellurides, and what are believed to be ammonosulfites, selenites, and tellurites, such as $S(NK)_2$. These compounds are the analogs of the sulfite, $OS(OK)_2$. In the case of sulfur, the ammono salts are complex in nature, and those of selenium and tellurium are very explosive. In the reactions of the fused amides (*13*) the ammono salts are unstable, and decompose,

evolving nitrogen in a similar manner as the halogens. The formation of complex ions such as S_x^{--}, Te_x^{--}, etc. ($S.S^{--}$, S_2S^{--}, S_3S^{--}, S_4S^{--}, etc.), does not change the theory of these reactions because it has been shown by Kraus (*14*) that such compounds are salts and that the excess of electronegative element (S, etc.) present in the homo-atomic anion appears to alter in no way the valence of the one electronegative element originally in the anion.

Ruff and Geisel (*15*), Franklin and Kraus (*16*), and Bergstrom (*17*) have found that sulfur slowly dissolves in liquid ammonia at ordinary temperatures without evolution of gas. It has been shown that sulfur reacts with ammonia in accordance with the equation

$$10S + 4NH_3 \longrightarrow 6H_2S + N_4S_4.$$

Ammonia forms ammonium sulfide with hydrogen sulfide and with nitrogen sulfide a mixture of two acids, $S(NH)_2$ and $S_2(NH)_2$, which may be regarded, respectively, as a sulfurous and a thiosulfuric acid of the ammonia system. The reaction is thus similar to the reaction of chlorine on water.

$$Cl_2 + H_2O \longrightarrow HCl + HOCl$$

Phosphorus reacts with sodium amide to form a polyphosphide and what is believed to be a sodium ammonophosphite, P(NNa)NHNa (*18*), analogous to sodium phosphite. The reaction with arsenic and antimony in solution (*18*) is similar, whereas when antimony and bismuth are fused with the amides (*13*), polyantimonides and polybismuthides are formed, and nitrogen is evolved, the ammonoantimonate and bismuthate being unstable at this temperature.

Carbon reacts with sodium amide around 500–600°C. to form disodium cyanamide and hydrogen.

$$2NaNH_2 + C \longrightarrow Na_2NCN + 2H_2 \ (19)$$

Near 800°C. the cyanamide reacts with the excess of carbon to form the cyanide.

$$Na_2NCN + C \longrightarrow 2NaCN \ (20)$$

These reactions seem to depend somewhat upon concentration because hydrogen and cyanamide are formed when sodium cyanide is dissolved in fused sodium amide at 400°C.

$$NaCN + NaNH_2 \longrightarrow Na_2NCN + H_2 \ (21)$$

Germanium also evolves hydrogen when treated with potassium amide, a mixture of ammonogermanite and germanate probably being formed (*13*).

Tin (*22*) and lead (*23*) react similarly, except that the polystannides and polyplumbides are stable and no hydrogen is evolved.

$$10Sn + 6KNH_2 \longrightarrow 2SnNK \cdot 2NH_3 + K_4Sn_8$$

By analogy, in the reaction with KOH, the stannide would be formed, which would decompose with the evolution of hydrogen.

$$2Sn + 8KOH \longrightarrow K_4SnO_4 + K_4Sn + 4H_2O$$
$$K_4Sn + 4H_2O \longrightarrow SnH_4 + 4KOH$$
$$SnH_4 \longrightarrow Sn + 2H_2$$

or $$SnH_4 + 2KOH + H_2O \longrightarrow K_2SnO_3 + 4H_2$$

In the case of lead, potassium polyplumbide, K_4Pb_9, and presumably potassium ammonoplumbite are formed.

Thus it can be shown that there are certain similarities in the reactions of non-metallic elements and bases. The reactions are generally analogous for sodium hydroxide and sodium amide, but varying as to the stability of the various products formed. The polystannides and similar compounds are much more stable in ammonia than in water, but the ammono salts are less stable than the corresponding aquo salts. The majority of these reactions are all of the same type, *i. e.*,

$$Cl_2 + 2NaOH \longrightarrow NaCl + NaOCl + H_2O$$

The mechanism of these reactions is not very clear, but it is possible to classify most of these reactions under a single type and thus clarify what might otherwise be a rather confusing and apparently diverse series of reactions.

The writer wishes to express his appreciation to Dr. W. C. Fernelius for his helpful suggestions and criticisms.

Literature Cited

(1) BERGSTROM, "Reactions of the Type $Cl_2 + 2KOH \longrightarrow KCl + KClO + H_2O$," *J. Phys. Chem.*, **30,** 12 (Jan., 1926).

(2) LEBEAU and DAMIENS, "Sur un nouveau mode de préparation du fluorure d'oxygène," *Compt. rend.*, **188,** 1253 (May, 1929); RUFF and MENZEL, *Z. anorg. Chem.*, **190,** 257 (1930).

(3) WINTER, "An Investigation of Sodamide and of Certain of Its Reaction Products," *J. Am. Chem. Soc.*, **26,** 1509 (Nov., 1904).

(4) FERNELIUS and JOHNSON, "Liquid Ammonia as a Solvent and the Ammonia System of Compounds. II. Inorganic Ammonia Compounds," J. CHEM. EDUC., **5,** 828 (July, 1928).

(5) FRANKLIN, "Potassium Ammonobarate, Ammonostrontiate and Ammonocalciate," *J. Am. Chem. Soc.*, **37,** 2298 (Oct., 1915).

(6) BERGSTROM, "Displacement of Metals from Solutions of Their Salts by Less Electropositive Elements. I. The Replacement of Sodium and Potassium by Magnesium and Aluminum," *ibid.*, **45,** 2278 (Dec., 1923).

(7) STRAIN, "Hydrobenzamide and Benzylidene Imine as Ammono Aldehydes," *ibid.*, **49,** 1563 (June, 1927).

(8) SACHS, "Eine neue Darstellungsweise für aromatische Amine," *Ber.*, **39,** 3006 (Sept., 1906).

(9) JOHNSON and FERNELIUS, "Liquid Ammonia as a Solvent and the Ammonia System of Compounds. V. The Properties of Solutions of Metallic Compounds in Liquid Ammonia," J. CHEM. EDUC., **7,** 981 (May, 1930).

(*10*) (*a*) EPHRAIM, "Zur Kenntnis des Natriumamids," *Z. anorg. Chem.*, **44,** 189 (Mar., 1905); (*b*) see ref. (*1*).

(*11*) MILES, "The Reaction between Sodamide and Hydrogen," *Proc. Roy. Soc. Edinburgh*, **35,** 134 (April, 1915); GUNTZ and BENOIT, "Sur l'amidure de sodium industriel," *Bull. soc. chim.* [4] **41,** 434 (1927).

(*12*) See ref. (*1*), p. 14.

(*13*) FERNELIUS and BERGSTROM, forthcoming publication.

(*14*) KRAUS, "The Constitution of Metallic Substances," *J. Am. Chem. Soc.*, **44,** 1216 (June, 1922).

(*15*) RUFF and GEISEL, "Das Sulfammonium und seine Beziehungen zum Schwefelstickstoff," *Ber.*, **38,** 2659 (1905).

(*16*) FRANKLIN and KRAUS, "Liquid Ammonia as a Solvent," *Am. Chem. J.*, **20,** 830 (Dec., 1898).

(*17*) BERGSTROM, "Solutions of the Electronegative Elements in Liquid Ammonia. I. The Action of Selenium, Tellurium, Arsenic and a Solution of Sulfur in Liquid Ammonia upon Cyanides," *J. Am. Chem. Soc.*, **48,** 2319 (Sept., 1926).

(*18*) (*a*) See ref. (*1*), p. 15; (*b*) see ref. (*13*).

(*19*) SVARVASY, "Electrolysis of the Nitrogen Hydrides and of Hydroxylamine," *J. Chem. Soc.*, **77,** 606 (1900); DENNIS and BROWNE, "Hydronitric Acid and the Inorganic Trinitrides," *J. Am. Chem. Soc.*, **26,** 588 (June, 1904).

(*20*) MARTIN, "Industrial Chemistry," Part II, Vol. I, D. Appleton and Co., New York City, **1915,** p. 486.

(*21*) "Verfahren zur Darstellung von Alkalicyanamid," D. R. P. 124,977, October 22, 1901 (see *Chem. Centr.*, **1901,** II, 1100).

(*22*) See ref. (*18*) (*a*).

(*23*) See ref. (*1*), p. 18.

Ginger Paralysis Cause Discovered in Phenol Compound. A substance related to carbolic acid is probably the adulterant which has caused thousands of cases of paralysis from drinking Jamaica ginger.

A phenol compound, probably the phosphoric acid ester of tricresol, is the substance which Dr. M. I. Smith of the U. S. Hygienic Laboratory, working with the Prohibition Bureau, found in samples of the ginger from shipments that had caused cases of the paralysis. Samples from shipments thought but not definitely known to have caused paralysis also contained this substance. Samples from lots that did not cause paralysis did not contain any of the phenol compound.

Samples from the first two classes of shipments were fed to rabbits, monkeys, and dogs. The monkey and dogs were not affected, but the rabbits became paralyzed in the limbs and died of respiratory failure.

An adulterated fluidextract of ginger was made in the laboratory to resemble the ginger that had caused the paralysis outbreaks in human beings. This extract contained tricresyl phosphate, the suspected compound. It had the same effect on the animals as the samples of the ginger which were known or thought to have caused the human disease.

The government scientists were at a loss to explain why the monkeys and dogs were not affected by the ginger samples, but they found that paralytic symptoms could be produced when the suspected phenol compound was broken down chemically before being given to the dogs and monkeys. This suggested that the compound passed through the stomachs of these animals unchanged, while in the stomachs of rabbits and of man it was broken down into a poisonous substance.—*Science Service*

EXORCISING A SPECTRE: ENTROPY

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A method is suggested whereby, for a system composed of perfect gases, entropy may be defined and its characteristics for reversible changes of state introduced without previous mention of the Second Law. Two parallel procedures are outlined, the one making use of the arbitrary reversible cycle and the other of the mathematical properties of the "integrating factor." Specific exercises are suggested designed to make the student familiar with the properties and concreteness of entropy, thereby avoiding the usual mental hazard raised by the abstruse nature of the Second Law itself.

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Entropy is a mystery of long standing to the neophyte in thermodynamics. It is bound up in some obscure way with an equally mysterious Second Law, which has the reputation of saying a great deal but which is actually as meaningless to the tyro as a magic alchemical recipe. This effect is heightened by the information that the Second Law has been disputed vehemently in the past and is unique among physical laws of the present and further is a law of probability rather than certainty. It follows that, mainly in consequence of the regrettable obscurity surrounding the Second Law itself, entropy, which is introduced as a function whose behavior is particularly suitable for expressing the content of the Second Law, becomes a sort of elusive ghost, half-seen and half-guessed at and wholly appalling.

Beyond question the mathematician's approach to the concept of entropy as the complete differential corresponding to the improper differential δq is far superior to the physical approach, but most students in chemical courses are, to put it mildly, inexpert mathematicians. Consequently, this elegant and convenient terminology is just about as easy for the student to handle as an old chemistry text in Latin. It is a pity to waste it, however, and in the method about to be described the meaning of the cabalistic mathematical terms is made obvious by means of familiar physical concepts, essential parts of the problem and not introduced *ad hoc*.

Probably the greatest advantage of the present method is that entropy is introduced and made quite familiar before the Second Law is mentioned so that it appears, not as a concomitant of that mystifying Second Law, but as a logical and convenient outgrowth of the First Law.

Integrating Factors

The most familiar and usual form of the First Law is

$$dE = \delta q - \delta w \qquad (1)$$

where δq represents the heat absorbed and δw the work done by a body during a small change of state. There is a fundamental difference (already

encountered by the student in considering specific heats) between dE on the one hand and δq and δw on the other. dE, the increment of internal energy, is independent of the path by which the body proceeds from the initial to the final state; δq and δw are not. In order that these latter may have a definite meaning it is essential to know the route by which the change takes place. Such quantities are known as improper differentials. They may be transformed into ordinary differentials by means of what is known as an integrating factor.

For example, we know from the mechanical laws governing changes of volume that, provided the change of state is reversible, δw may be replaced by pdv where p is the equilibrium pressure at the instant and dv is the change in volume experienced by the body. Now dv is an ordinary (complete) differential, because the numerical value of the volume of a body is independent of any previous values; in other words, does not depend on how it got that way, so that $\delta w/p = dv$ is also a complete differential. That is to say that multiplying δw by $1/p$ has changed it from an improper to a complete differential: $1/p$ is an *integrating factor* for δw.

The advantage of knowing the integrating factor is that, when improper differentials have been replaced by complete differentials, ordinary integration becomes possible so that we can calculate the work done by the body on any path if we know the end-points of the path and the equation of state of the body. Pursuing the investigation still farther, let us search for an integrating factor for δq.

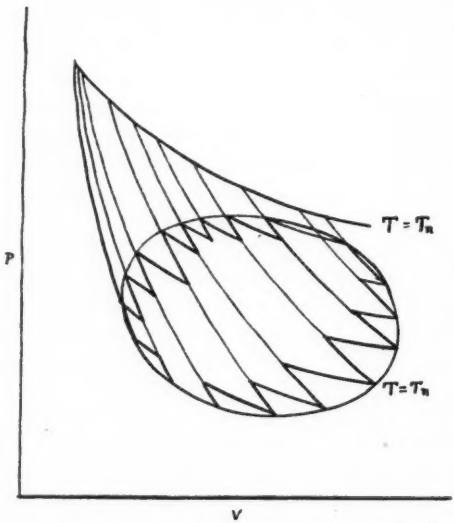
It happens that, reasoning by analogy, the answer may be correctly predicted. The substitution of pdv for δw is only one instance of a general physical practice; in general, δw is replaced by the product of *force* into *change of coördinate.* If the work is mechanical as in lifting a weight, $\delta w = Fds$; if as in expansion, $\delta w = pdv$; if electrical, $E^\circ de$, where E° is the potential and de the increment of charge; and so forth. Now the "potential" or "force" of heat is temperature so that, by analogy, $\delta q = TdS$, where S is some (unknown at present) "point function" like E or v.* Such reasoning by analogy must be substantiated by a real proof, which is readily obtainable for the special case of a perfect gas.

Method of the Arbitrary Reversible Cycle (A)

Consider an arbitrary reversible cycle in which the working substance, W, is a perfect gas. This may be represented in, say, a p-v diagram by means of a closed curve (*cf.* figure). Subdivide this curve into a large number of small segments. As the point representing the state of W traverses one of these small segments, the gas does work δw and absorbs heat δq. Such a cycle may be conveniently replaced by the equivalent cycle formed by drawing through each point of division the corresponding adiabatic and isothermal of the gas W. The proof that the original cycle and this new

one formed of segments of isothermals and adiabatics approach identity as the number of subdivisions becomes very large is straightforward (*1*), and may even be based, of course not very rigorously, on the same intuitive geometrical grounds which are employed in teaching elementary integration to convey the idea of the area under a curve as the limit of the sum of a series of narrow rectangles.*

Each segment of the original cycle has now been replaced by a broken curve consisting of a segment of an isothermal and a segment of an adiabatic. The quantity of heat, δq, absorbed during the traversal of the segment of the original cycle must now be absorbed during the traversal of the corresponding isothermal segment, because no heat is exchanged with the surroundings during the traversal of an adiabatic. As a convenient *source* of heat, choose a reservoir R maintained at the constant temperature T_R, and let the heat be transferred from R to W by means of a perfect gas G performing a series of Carnot cycles such that the upper temperature of all of them is T_R and the lower temperature of, say, the nth is T_n, equal to that of the nth isothermal segment. If, as we assume, we use one mole of G and one mole of W, then the corresponding isothermals and adiabatics of the two gases coincide. In order that the gas G used to transport the heat may give up to W the quantity of heat δq_n at a temperature T_n, it must have taken from the reservoir R an amount of heat



The closed curve represents the original cycle, the heavy zig-zag line the new one formed of segments of isothermals and adiabatics. The isothermal of the heat reservoir serving as source is the heavy one marked $T = T_R$. The angle between the isothermals and adiabatics is purposely exaggerated to facilitate visualization.

* As the points of subdivision become closer and closer together the dimensions and areas of the many small triangles, which, in their sum, represent the difference between the quantities of work done during the old and new cycles, approach zero; but the areas, being of two dimensions, become small quantities of the second order and so are negligible compared with the linear dimensions which are small quantities of the first order. Hence the sum of the areas of all the triangles approaches zero and the cycles approach identity.

$$\delta q'_n = T_R \delta q / T_n \tag{2}$$

by the formula for the efficiency of the Carnot cycle for a perfect gas. When the whole cycle has been traversed, the total amount of heat taken from R must be

$$\begin{aligned} Q &= \Sigma \delta q'_n = T_R \Sigma \delta q_n / T_n \\ &= T_R \oint \delta q / T \end{aligned} \tag{3}$$

if the subdivision has been carried to the limit. This amount of heat must, by the First Law, equal the total work done by W and G, and this work may also be set equal to the area enclosed by the paths traversed by W and G, due regard being taken to the sign of the area. By tracing the paths (see figure) it is found that W traverses the cycle once in one direction, G traverses the same cycle once in the reverse direction, and the other quantities of work performed by G in traversing the various Carnot cycles exactly cancel each other. The total work done is *zero*. Consequently, $Q = 0$, and

$$\oint \delta q / T = 0 \tag{4}$$

It is, of course, easy to show that any quantity the integral of which around a closed path is zero is a complete differential. The procedure is usually presented to the class in treating of the properties of dE as distinguished from δq or δw. It follows that

$$\delta q / T = dS \tag{5}$$

where S is a point function which we may name entropy. Thus, as had been anticipated, $1/T$ is an integrating factor for δq, and the First Law may be expressed

$$dE = TdS - pdv \tag{6}$$

for a reversible change of state of a perfect gas.

The above method of procedure has two advantages to offset its somewhat cumbersome nature. It is geometrical and therefore picturesque and plausible, and it serves admirably as a starting point from which to generalize entropy as a function of *any* substance (*1*).

Method of the Integrating Factor (B)

This same result could have been arrived at much more quickly and (mathematically) much more simply as follows. In any reversible change of state

$$\begin{aligned} \delta q &= dE + pdv \\ &= (\partial E/\partial T)_v dT + [(\partial E/\partial v)_T + p]dv \end{aligned} \tag{7}$$

and, for a perfect gas,

$$pv = RT;\ E = \text{const.} \times T \tag{8}$$

so that

$$p = RT/v,\ (\partial E/\partial T)_v = C_v = \text{const.},\ (\partial E/\partial v)_T = 0 \tag{9}$$

Hence,

$$\delta q = C_v dT + RT\, dv/v. \tag{10}$$

Now, in general, if dz is a perfect differential,

$$dz = \partial z/\partial x \quad dx + \partial z/\partial y\, dy \tag{11}$$

and

$$\partial/\partial y\ (\partial z/\partial x) = \partial/\partial x\ (\partial z/\partial y) \tag{12}$$

If, by multiplying (10) by a factor β, obtaining

$$\beta\delta q = \beta C_v dT + \beta RT\, dv/v \tag{13}$$

we can show that

$$\partial/\partial v\ (\beta C_v) = \partial/\partial T\ (\beta RT/v) \tag{14}$$

then

$$\beta\delta q = dS \tag{15}$$

where dS is a perfect differential. Now it is obvious that, if $\beta = 1/T$, (15) is satisfied, for both sides reduce to zero.
Hence

$$dS = \delta q/T = C_v dlnT + Rdlnv \tag{16}$$

where S is a point function, $S(T,v)$.

Nailing Entropy Down

Either of the methods, **A** or **B**, may be employed profitably. To a class familiar with the concepts of engineering and indicator diagrams method **A**, making use of a diagrammatic calculation of the work done, will appear more plausible and convincing. To a class more familiar with mathematical analysis and fresh from a course in the calculus, method **B** would be preferable. The really important point is that entropy may be introduced in this way apart from the Second Law, owing its existence to concepts with which the student is familiar: work, heat, the perfect gas, the First Law.

Entropy may also be made to lose its mystical vagueness of outline and to assume a character quite as concrete as that of any other thermodynamic function. It may be pointed out that we are generally interested in particular types of curves such as isothermals, isobars, isometrics, adiabatics. Along a curve of each type some important function is held constant, *e. g.*, T, v, p. (It is convenient, although of course inessential, to introduce the term parameter.) Along an adiabatic S is held constant; adiabatics may be called "isentropics." With such an introduction S ranks, in the mind of the student, with T, p, v, E in importance and also, I believe, understandability.

As a final step in developing concreteness the exercise may be given to draw, in a p-v, p-T, or T-v diagram, a system of isentropics, each labeled

with its proper numerical value of entropy (calculated from any convenient "line of zero entropy") in imitation of the usual diagram of labeled isothermals, and this may be followed by the introduction of the S-T diagram, which, important in itself and usually entirely overlooked in a short course, automatically raises S from obscurity to the rank of a definite quantity capable of taking on definite numerical values. The process of plotting a system of isobars in the S-T diagram is a very great aid in making entropy a familiar and usable tool.

This method of introduction, somewhat modified, is being used in teaching the course in thermodynamics offered to candidates for the master's degree in chemistry. It is found that, even after the preliminary treatment of thermodynamics received as undergraduates in courses on heat engines or physical chemistry, the student is likely to have only the vaguest notion of what entropy is or stands for and is prone to use formulas without attempting to master their full content and significance. The method outlined here is offered in the hope that it may be of use elsewhere.

Literature Cited

(1) GEIGER and SCHEEL, "Handbuch der Physik," Julius Springer Berlin, 1926, vol. IX, p. 51.

Ultra-Violet Shows Up the Check Raiser. The treatment of check paper with aesculin, a white powder obtained from the bark of the horsechestnut tree, makes it possible for the bank teller to detect with ease erasures and changes which otherwise might escape notice.

Aesculin fluoresces, or glows, when placed under ultra-violet light. An erasure on paper treated with this substance would show up as a dark spot on an otherwise luminous surface. A patent on the process has recently been granted to Dr. D. Julian Block. —*Science Service*

Good Students Found to Be Rapid Readers. The college student who doesn't know how to study may now be told to have his eye-motions photographed. For these eye photographs may show that he glances back frequently, instead of fixing his eye effectively on each new group of words. The photographs may show that he reads very slowly and pauses many times as his eye moves across the page.

That inefficient reading habits, such as these, link with weak study habits is found by two psychologists, Dr. W. R. Miles and H. M. Bell, who have photographed the eye movements of university students as they read a difficult passage on "didactic poetry." The students' speed in completing the paragraph was compared with their scholastic ability.

The most rapid readers sped along about twice as fast as the slowest, it was found. These fast readers as a rule showed the most extensive spans of print taken in by the eye at one fixation before it moves to take in the next group of words. The fast readers looked back fewer times to correct inaccuracies in their fixation.

Readers look back most frequently at the middle or right end of a line of print, the experiments indicate.—*Science Service*

WHAT ARE CHAIN REACTIONS?

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Consecutive reactions that repeat their cycle many times after being initiated are called chain reactions. The termination of a chain occurs when one of the components of the set is removed permanently or suffers an energy loss sufficient to prevent its continued reaction. In case the number of chains initiated per unit time is greater than those terminated the reaction may increase to explosive proportions. Chains may be initiated by a variety of methods: photochemical, α-particle and electron collisions, and chemical. The photochemical equivalence law affords a means of estimating the number of chains started.

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Scientific curiosity was not long satisfied with knowing what substances result from chemical changes. It began quickly to delve into the nature of the process itself to see by which of a possible variety of paths the action may proceed. Certain simple organic and inorganic reactions were found to take "concurrently" a number of paths to the production of a single substance in one case, or, in another, of an equal variety of products.

The path of the lead chamber process for sulfuric acid was fairly well indicated by the isolation of the intermediate compound. The rates of formation and decomposition of this compound determine the rate of formation of the final product. In the event the amount of the intermediate is insufficient for observation it still determines the rate of the reaction. In the case of an unexplained mechanism a similar intermediate could be assumed and if the observations on the rate of formation of the final product were compatible with the assumption then we have "elucidated" the mechanism of the reaction. Such mechanisms in which an essential component enters into the reaction yet remains constant by being regenerated are "catalytic" are in our present sense "chain" mechanisms.

A reaction that has long been of interest is that of hydrogen and oxygen and it is also typical of those reactions that are so fast as to be explosive. Mixtures of hydrogen and oxygen at room temperature are indifferent until a catalyst or local heating induces reaction after which the catalyst is unnecessary. The reaction proceeds throughout the mixture at a rate which increases to a constant value. "Hot" molecules produced by the initial heating and by the heat evolved might be suggested as the induction mechanism. Another reaction of this type is the formation of hydrogen chloride. It can be initiated by a variety of different and fairly well understood methods which indicate that such simple formulations as

$$2H_2 + O_2 = 2H_2O$$
$$H_2 + Cl_2 = 2HCl$$

are quite inadequate. Light has long been known to induce reaction in mixtures of hydrogen and chlorine, one light corpuscle being able to cause

the reaction of a million molecules of chlorine. It is generally believed that the light corpuscle, or quantum, should be capable of causing just the one chlorine molecule to react by which it has been absorbed (the Einstein law of photochemical equivalence). It is of especial significance that the total change is proportional to the number of quanta absorbed, that is, a process of definite duration has occurred for each quantum. The chlorine molecule has become a catalyst whose activity is maintained until a million molecules have reacted. A closer examination has been made possible by the concept of chain mechanisms. This requires an initial process yielding an "active" substance that proceeds through a set of individually known or assumed consecutive reactions to the regeneration of the active product which repeats the process. The following set of reactions has been proposed:

$$\begin{aligned} Cl_2 &= 2Cl \text{ (initial light reaction)} \\ Cl + H_2 &\longrightarrow HCl + H \\ H + Cl_2 &\longrightarrow HCl + Cl \\ H + HCl &\longrightarrow H_2 + Cl \\ H + H &\longrightarrow H_2 \\ Cl + Cl &\longrightarrow Cl_2 \\ H + Cl &\longrightarrow HCl \end{aligned}$$

The most satisfactory example of a chain reaction is the thermal and photochemical formation of hydrogen bromide. The mechanism is similar to that above.

$$\begin{aligned} Br_2 &\longrightarrow 2Br && (1) \\ Br + H_2 &\longrightarrow HBr + H && (2) \\ H + Br_2 &\longrightarrow HBr + Br && (3) \\ H + HBr &\longrightarrow H_2 + Br && (4) \\ H + Br &\longrightarrow HBr && (5) \\ H + H &\longrightarrow H_2 && (6) \\ Br + Br &\longrightarrow Br_2 && (7) \end{aligned}$$

Each of these reactions can be realized separately. (1) and (7) simply represent the dissociation and association of bromine. Atomic hydrogen reacts readily with itself, with bromine, and with hydrogen bromide. (2) is the reverse of (3) and the probability of occurrence will depend upon the relative concentrations and the velocity constants. The chain would be terminated by (5), (6), and (7), and also on the walls if the pressure is so low that the atomic species will reach the walls before collision with reacting molecules. The intermediate products and processes cannot be isolated so that their plausibility must be determined from rate reactions. Analysis of the set of reactions (*1*) indicates that the rate of formation of hydrogen bromide should proceed as follows:

$$\frac{d(HBr)}{dt} = \frac{2k_2(H_2)\sqrt{\frac{k_1}{k_7}(Br_2)}}{1 + \frac{k_4}{k_2}\frac{(HBr)}{(Br_2)}}$$

The constants for the corresponding reactions can be consolidated for comparison with experiment. The experimental examination by Bodenstein and his students (*2*) resulted in an equation for both the thermal and photochemical rates that is identical with the theoretical equation, thus affording a strong basis for the mechanism.

If this suggested mechanism is the true one then certain consequences should be observed as the temperature is changed. The initiation of chains in the thermal reaction is determinated by the bromine dissociation and in the photochemical reaction by absorbed quanta in addition. Their termination is the same in both. The readiness with which bromine atoms react with hydrogen molecules as well as the production of bromine atoms are greatly dependent upon the temperature, the reactions being endothermic. Absorption of light quanta by bromine molecules and their subsequent dissociation are practically independent of the temperature. From knowledge of the energies of activation and their established relation to the rate of the reaction* the effect of a temperature increase can be predicted. This predicted increase in the number of chains and their greater length, that is, increase in the reaction rate, has been verified by experiment thus further increasing our confidence in the proposed mechanism.

The hydrogen chloride formation should proceed in a similar manner, yet over a century of persistent effort has not sufficed to give an adequate account of the reaction. It is peculiarly sensitive to very small traces of different substances. For example, ammonia retards the rate initially, and oxygen permanently inversely as its concentration; the water vapor must be more than 10^{-7} mm. for reaction to occur. As a consequence much contradictory and divergent experimental and theoretical work has been done. The thermal reaction is of little assistance, as few of its complications can be correlated with those of the photochemical reaction. Such varied findings have been explained by a similar variety of chain mechanisms. For instance, oxygen reacts with the chlorine or hydrogen atoms as follows:

$$\begin{aligned} Cl + O_2 &\longrightarrow ClO_2 \\ ClO_2 + Cl &\longrightarrow Cl_2 + O_2 \end{aligned} \qquad \begin{aligned} H + O_2 &\longrightarrow HO_2 \\ H + HO_2 &\longrightarrow H_2 + O_2 \end{aligned}$$

resulting in a negative "catalytic" effect. Water is necessary in the first part of the chain so we have an attempted explanation in

$$\begin{aligned} Cl + H_2O &\longrightarrow HCl + OH \\ OH + H_2 &\longrightarrow H_2O + H \\ H + Cl_2 &\longrightarrow HCl + Cl \end{aligned}$$

* The empirical relation of Arrhenius, $d \ln k/dT = A/RT^2$, where k is the velocity constant and A the heat of activation.

where the water molecule is a positive catalyst. The initial stage of the reaction is also uncertain, it being difficult to decide whether the original reaction is*

$$Cl_2 + h\nu \longrightarrow 2Cl$$

or

$$Cl_2 + h\nu \longrightarrow Cl'_2$$

Some other interesting methods of initiating chains in the hydrogen chlorine mixture have been investigated recently. If hydrogen is introduced into a reacting mixture of sodium vapor and chlorine, then hydrogen chloride and sodium result. It has been established that

$$Na + Cl_2 \longrightarrow NaCl + Cl$$

and the Cl would produce a chain as previously outlined. The amount of hydrogen chloride formed was upward of two hundred times that of the sodium chloride which is about the same yield for the photochemical formation under the same conditions.

Direct introduction of hydrogen atoms as from a discharge tube into a hydrogen chlorine mixture will accomplish the synthesis of hydrogen chloride thus,

$$H + Cl_2 \longrightarrow HCl + Cl,$$

and the chain is started. It is difficult, however, to get quantitative information concerning the number and length of the chains in this case.

A further interesting method of inducing reaction is by the action of α particles. The well-known primary result of the collision of an α particle with the gas molecules is ionization of the gas

$$Cl_2 \longrightarrow Cl_2^+ + \epsilon.$$

The fate of the electron can be represented by

$$Cl_2^+ + \epsilon \longrightarrow Cl_2$$
$$Cl_2^+ + \epsilon \longrightarrow Cl_2^-,$$

the probability of the second reactions occurring in this or other cases will depend upon the nature of the gas. In chlorine and oxygen, for example, one attachment results after more than a thousand collisions while the molecule H_2^- is extremely improbable. In case other molecules are present the ionized products may undergo or may induce reaction. In the hydrogen chlorine mixture the reaction is certainly induced. The number of ions produced by the passing of one α particle into the gas is known with considerable exactness and the number of hydrogen chloride molecules produced is found to be many times the number of original ions formed. The number in fact is about twice as many per ion pair as previously found per quantum. It has been found recently also that the effect of

* h is Planck's constant and ν the frequency of light, their product representing the energy in one quantum.

the temperature on the photochemical and radiochemical reactions is the same. Since the primary acts are in each case not significantly affected by a change in temperature the same temperature coefficient strongly suggests a similar subsequent process and attempts have been made to show the generation of the previously suggested atomic species from the gas ions.

This similarity of result with light quanta and α particles has also been found for the phosgene reaction

$$CO + Cl_2 \longrightarrow COCl_2,$$

which is also believed to have a chain mechanism. The reactions proceed in precisely the same manner and with the same yield per quantum as per original ion pair.

Now, if in a reacting mixture the number of chains being initiated is greater than the number terminated the reaction might develop into an explosion. This would be a chain mechanism of an explosion and an attempt has been made recently (*3*) to apply this view more closely. The reaction front in detonating gas mixtures increases in speed to a constant maximum, the velocity of the explosion wave, which is 1763 meters per second for the hydrogen chlorine mixture. This can be assumed to be the velocity of a chlorine atom in the direction of observation. Very satisfactory agreements have been found between this assumed velocity of the chlorine atom and that calculated from the thermochemical data. It is suggested that the OH molecule "carries" the wave in the hydrogen oxygen explosion:

$$\begin{aligned} H_2 + O_2 &\longrightarrow 2OH \\ OH + H_2 &\longrightarrow H_2O + H \\ H + O_2 + H_2 &\longrightarrow H_2O + OH \\ OH + H_2 &\longrightarrow \text{etc.} \end{aligned}$$

In a number of oxidations atomic oxygen is assumed to be the "carrier."

The idea of reaction chains has been extended to both thermal and photochemical reactions in solution in explanation of certain abnormal quantum yields and large positive or negative catalytic effects. Extremely small amounts of particular substances produce effects that are far out of proportion to their quantity. In the oxidation of sodium sulfite the retardation by alcohol is explained as a breaking of the chain by a permanent removal of the active component. In many cases the solvent effects seem difficult to interpret.

In conclusion it might be observed that the idea of chain reactions has been a very useful instrument in conjunction with the law of photochemical equivalence which gives a good theoretical basis for the number of such chains initiated.

Literature Cited

(1) CHRISTIANSEN, *Danske. Vid. Math. Phys. Medd.*, **1**, 14 (1919); HERZFELD, *Z. Elektrochem.*, **25**, 301 (1919), *Ann. Physik*, **59**, 635 (1919); POLANYI, *Z. Elektrochem.*, **26**, 50 (1920).

(2) BODENSTEIN and LÜTKEMEYER, *Z. physik. Chem.*, **121**, 127 (1926); BODENSTEIN and LIND, *ibid.*, **57**, 168 (1907).

(3) LEWIS, B., *J. Am. Chem. Soc.*, **52**, 3120 (1930).

AN INEXPENSIVE, EFFICIENT LABORATORY ASPIRATOR PUMP

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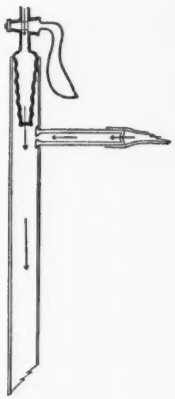
The aspirator pump has various practical applications in the chemistry laboratory. Among these might be mentioned its use for general filtration, distillation, vacuum, and pressure (*1*) purposes.

The pump described herewith is made of the simplest laboratory equipment. The cost is almost negligible. It will be found to be most convenient around any general laboratory where the demands are not too exacting. However, this pump will produce a surprisingly high or low pressure when attached to the usual water supply. The apparatus consists of a piece of $^5/_8$-inch pressure rubber tubing about 12 inches long and a piece of 6-mm. glass tubing about 2 inches long with a shoulder at one end formed by heating and pressing the end of the tube against the base of a ring stand. The glass tube is introduced through a small hole in the side of the rubber tubing and secured firmly in place with adhesive tape or similar material. A piece of $^3/_8$-inch rubber tubing connects the 6-mm. glass tube to a trap. The trap is then connected to a 4-oz. bottle which contains a double-hole stopper, 60-degree funnel, and a 6-mm. right-angle glass bend.



The pipe is connected at its upper end to a faucet furnishing water from the city pipes. The faucet is greatly constricted at the end and the air pressure is reduced far below atmospheric pressure. The vessel to be evacuated is, as stated above, connected to the pump by the side tube.

Literature Cited

(1) HOSHALL, "Apparatus for Supplying Air under Pressure," J. CHEM. EDUC., 7, 2674 (Nov., 1930).

CHANGING ATTITUDES IN THE HISTORY OF CHEMISTRY*

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The rapid development of chemistry at any particular period of history has depended upon the general attitude of the world at that time and is not so much a development due to some particular discovery. The changing attitudes in history have brought about the changing periods of chemistry. This is illustrated in detail for the ordinarily used periods of the history of chemistry.

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We are accustomed to ascribe any general advance in the science of chemistry to the activity following some outstanding discovery. Some investigator, either scientifically or accidentally, made some discovery which to us seems epoch-making since it has been written about and we have talked so much about it and have given it so much prominence. We conclude that the advancement in the science must have come about simply because of this discovery. Sometimes it is a group of men who have given forth a new theory; at least we are willing to include more than one as being responsible for it. We say this event or this theory or law marks the sudden expansion of the science.

Such circumstances as these which have been mentioned no doubt had some bearing upon the development of the science of chemistry. However, there are major facts in the general attitude of mankind at different periods which have just as important bearings upon the immediate development of the science as had the facts within the science itself. It is proposed to call attention to some of these attitudes and to note how the science of chemistry was developed by satisfying the desires of people in general.

The history of chemistry has quite commonly been divided into the following periods: (1) The Ancient Period, (2) The Period of Alchemy, (3) The Medical Period, (4) The Phlogiston Period, (5) The Oxygen Period, (6) The Electron Period.

Considering the Ancient Period, let us ask the question: What was the attitude of people in general and what was the effect of this attitude on scientific development? In those times people thought that nature was the work of the gods, and that it was irreverent to investigate or disturb it. They thought that the gods worked at random and carried out passing whims. This led to the idea of four primary elements which were likely at any moment to change into each other according to the whims of the gods. There were interesting discoveries. Men ventured to set forth theories which might have been fruitful in immediate scientific growth, but the attitude of men in general was not favorable to growth. It was the thoughts of men who were not making experiments that prevented development. Naturally progress was therefore mostly accidental.

* Presented before the Division of History of Chemistry of the American Chemical Society at Columbus, Ohio, April 30, 1929.

As years went by men awakened to the fact that nature might be looked into. There was a universal longing for life and a continuous and extended life. There was a universal longing for money which might be obtained with little or no effort. These universal desires (not scientific desires) led men to look about them and to try to gratify their desires for life and money by some prying into the secrets of nature. Nature must know these things and nature must have the secrets in her hands. There followed these common desires a quest for the Philosopher's Stone and The Elixir of Life; quests which took men through many dangers seeking for the fountain of youth, and led men to many experiments to try to make gold from cheaper metals or common things. Surely these quests were not the outcome of some great chemical discovery, but they led men to experiment and to try to investigate. Men were willing to finance these searchings and many were led to engage in them, and thus we have the story of the long Period of Alchemy.

These quests for the one substance of magical value which would give life eternal, and the one substance or principle which would give gold without limit failed, but in the search men found remedies for diseases and men found metals and their salts. The world then changed its notion or attitude and said there must be many remedies for the many diseases; maybe a particular remedy for each disease. Mankind was calling for these remedies and the chemists entered upon the search with the Medical Period of chemistry as the result. Paracelsus was a leader and blazed the way, but the world was calling for the very activity upon which Paracelsus and his followers entered. It was not started by the incentive of some revolutionary discovery in the science, but it was from the changing attitude of mankind. Mankind has not lost this attitude and the search still continues. The attitude of mind is that each disease or affliction of mankind has its remedy, and we are right in the midst of the activities which come naturally from this attitude of mind. If it is a germ, we look for an antitoxin; if a condition of blood, we look for the chemical which will supply the lacking material; if it is a letting down of some bodily process, we search for the stimulus to right the condition. We have the attitude of mind that there is a cure for each wrong condition if we can only find it. Before, it was a general cure for all wrong conditions. One brought about the seeking for a general cure, the other brings about the seeking for many cures.

The period following the so-called Iatro Period or Medical Period we designate as a period because it was a time when a peculiar notion existed as to the nature of combustion. In the developments of the preceding period many questions arose which men tried to answer. This one of explaining fire was an outstanding one, and in the light of later events was the leading problem of the time, but it was not due to some sudden discovery

of some chemist or some group of chemists. It came about in a time when men were asking questions about everything. They wanted to know the foundation of religion, of statecraft, of philosophy and, naturally, of science too. It was the questioning of men in general that led to the suggestion of a theory of combustion, not simply the questioning of some great chemist. New continents had been discovered, new laws about physical and astronomical things had been laid down. The world was looking for the reason for things and for a broader view of the phenomena of nature.

As this Phlogiston Period went on apace, more and more did men go into the search for fundamental reasons for chemical facts. The world asked for men who would go into this work and had them installed in educational centers. The universal demand for fixed and definite conclusions induced men in private life to set up laboratories or working places. There was the same agitation in political life. "Are kings necessary?" they asked. There came on the French restlessness, the American Revolution, the enlarging of citizens' rights. If there was activity in these other lines, why not in chemistry? Yes, important things did come from this activity; the discovery of hydrogen, the discovery of oxygen, and all the other outstanding discoveries of the times; but, mind you, there were more men working along these lines at this time than there were forty years after the time of these discoveries. The world was demanding such things; the attitude was to go forward and to know. The discovery of oxygen was not the cause; it was only one of the events resulting from this great push of mankind.

The modern idea that everything is fixed and unchangeable came about when laws were discovered and laid down; ultimate particles that are fixed and unchanging, elements which cannot be subdivided, compounds always the same. At the present time we are apparently emerging from this attitude of mind and going over to an attitude that would regard matter as always changing. In this attitude of mind elements and compounds are only a place or step in the eternal changing. We are jumping to guesses such as believing that matter and energy are one and the same thing. We are still measuring velocities, charges, colors, activities, resistances, and whatnot, but, after all, these are only relativities and just a part of the cosmic changes. These things are constants for us, for time for them may be measured in thousands of milleniums, but for us it is in minutes. What is time anyway? Some have the attitude now that things are only definite and fixed for a limited time, and that all is subject to change.

In political life we are still in the period of laws, laws, laws, with legislators thinking they are gods. If political, social, religious, and scientific attitudes all kept marching in step, these changing attitudes would not come into conflict with each other, but one changes slowly and another more rapidly and hence the two are in different stages at a given time and

there is a conflict. Science has changed its viewpoint or attitude toward nature and hence its methods for the study of nature change.

The attitude of religion toward science has changed. In early times it was believed that those who were trying to investigate nature were sacrilegious and should be suppressed. That attitude is still in the minds of some. Now, however, religion has the attitude of saying to the scientist, study, investigate, find out, set up theories, and verify or disprove them.

We try to get some chemical fact or set of facts to locate another period or other periods of chemistry, but where shall we locate the beginning of the period? Shall we say the beginning of organic chemistry, or the discovery of germs, and germicides, or the acceptance of the atomic theory, or the birth of agricultural chemistry, or the rise of physical chemistry, or the meeting with colloids, or the advent of the electron, or the discovery of radium; where shall we locate the periods? We have this difficulty because we still have the same attitude of mankind that we had a century and a half ago, namely, mankind wants to know, they want nature investigated and investigated to the limit, they are willing to give up old notions and to listen to new theories—so we are still in the period which led to the discovery of oxygen and to the rise of organic chemistry and all the rest. The science is growing because of the attitude of the world.

At no time did the attitude of men in general have more effect than just before and during the early days of the oxygen theory of combustion. It was a time of trying new theories, of trying to get away from the things of the past. This feeling affected the political life and led men to give themselves to the study of national life. Our Revolution was one of the episodes along this line. It led men to wander from the accepted theories in religion and to preach new notions. It led men to study physical nature and we had the numerous workers in chemistry who found hydrogen and oxygen and the alkali metals and many other new things. Men made over the methods of talking and writing about chemical elements and their compounds. Just as our nation was started in its independent existence, chemistry was really started in its independent existence and it has been developing rapidly ever since.

Let me speak of another attitude and its bearing upon our science of chemistry. One hundred years ago the world was interested in chemistry but it was not asking the chemist to make over the manufacturing activities. In the century how the attitude has changed, in fact it has changed in the last forty years. Some manufacturers were led to try out the possibilities of having their crude materials and products examined by a chemist. They found that it paid them financially. Others learned of the fact that it paid and they tried. Then the chemist told them where they could better their processes or could adopt new processes, and this paid too. Today the attitude of the commercial world is that chemistry

can solve her problems for her and so she is calling for chemists in almost every line of manufacturing or commercial endeavor, and we have the present outstanding developments in industrial chemistry. When the world changed its attitude the industrial chemist became a reality. Forty years ago there were very few of those who were then called "dollar chemists" because the world was not asking for industrial chemists. Today they are numbered by the thousands because the world has changed its attitude and is asking for industrial chemists. It pays them to guarantee this army of industrial chemists and the world is looking for more of them.

The fact that a given development or discovery in chemistry may have had a decided influence on the development of the science in the years following that discovery is not overlooked. For example, the discovery of anesthetics led to wonderful developments in medical chemistry. Anesthetics made operations possible and operations called for more and better anesthetics, for antiseptics, for better tools, for a knowledge of the chemistry of internal secretions, and many other things. Such developments are not to be ignored, but back of these discoveries there was a major influence in the attitude of mankind toward the things which belonged to the realm of chemistry. These different attitudes at different historical periods had the deciding influence on whether or not there should follow a development of the science or of a given branch of it.

Not always did a radical change in the attitude of the world toward a given activity affect all activities. Neither did a period of decided change in the world attitude in general affect all activities in exactly the same years. New political attitudes might either precede or follow religious attitudes by a few years, hence new and decided changes in the scientific attitude might precede or follow the changes in other activities by a few years. The Reformation made a decided change in the world attitude on religion. It had a profound influence on education and freedom of thought but it did not make a decided change in science. It did make a decided change in that it awakened mankind to a new adventure but it did not change the ideas as to methods of governments. So we are led to observe that it was the attitude of mankind toward the things involved in the science of chemistry which brought about radical changes when the desires of men changed. Mankind in general did not know or realize that their changing notions would have any such bearing, nor did they think in terms of the advances which came as a sequence to their desires.

Again it may be said that particular discoveries have often immediate effects and sometimes very decided delayed effects upon the development of the science, but far more decided and universal in their effects are the attitudes of humanity toward the things of life and the things of nature. These changing attitudes are the fundamental causes of scientific developments.

INTRODUCING AN OLD BOOK TO NEW FRIENDS

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A resumé is given of the early history of the United States Pharmacopœia with particular reference to American chemists who have played an important part in the preparation of this volume. The materials contained in the U. S. P. which would be of particular value to the laboratory man are stressed, pointing out the various tables for the identification and standardization of chemicals. How this volume may be used by the laboratory man in many fields of science, as a general reference book for chemicals and drugs, is described.

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In January, 1817, Dr. Lyman Spalding of New York City submitted to the Medical Society of the County of New York a project for the formation of a United States Pharmacopœia. At this time (1817) there was no generally recognized and authoritative standard for drugs in use in this country. Various European pharmacopœias no doubt found popular usage in the more thickly settled eastern states. Possibly the most famous and popular was the London Pharmacopœia which had been established in 1618. As a result of Dr. Spalding's effort a National Pharmacopœia was prepared by delegates from the various states of the Union who met in a general convention in Washington on January 1, 1820. Before adjourning, the convention made arrangements for the future revision of its work, which appeared in 1821, and provided for a second convention to meet in 1830 and every ten years thereafter in order to keep the volume in accordance with the most recent scientific developments.

Dr. Lyman Spalding

In May, 1930, one hundred and ten years after the first Pharmacopœial Convention, a large group of scientists composed of many of the country's best chemists, pharmacists, botanists, and physicians met to start the preparation of the United States Pharmacopœia Eleven. After a proper revision of the U. S. P. X has been made the new U. S. P. XI will appear; this work of revision will require approximately six years.*

There are many unusual features about our Pharmacopœia which make

* Copies of the U. S. P. X may be obtained from J. B. Lippincott Co., Philadelphia, Pa.

it interesting as a book as well as a valuable aid to pharmacist, chemist, and physician. American pharmacy handles this treatise in a noteworthy way, for the members of the profession coöperate splendidly to accomplish the enormous amount of work required to revise it every decade. As evidence of appreciation of this careful work the government has completely endorsed the Pharmacopœia as the law governing the standards for drugs and medicines. The Pure Food and Drugs Act of 1906 adopted the Pharmacopœia as the standard for drugs in the United States. Possibly there is no other group of non-congressional men who prepare a set of standards for drugs which automatically become national in scope upon its publication. The standards so prescribed must be adhered to by the manufacturing pharmacist to avoid prosecution by the state and federal authorities. In this way the very obviously necessary uniformity of drugs is maintained.

Occasionally one sees in a chemical journal a short article written by a chemist who has "discovered" a very useful and valuable book, wherein he finds numerous tables of helpful information for this particular type of work. These discoveries, upon close scrutiny, one finds are often volumes of pharmacopeias of ancient vintage. After seeing several of such articles the author decided that a brief descriptive composition, outlining the features of the Pharmacopœia which are of particular interest to the chemist, would be in order.

From acacia, which is the first official drug, to zingiber (ginger), which is last, the descriptions of various chemicals and drugs are of a particularly valuable nature for they would be difficult to obtain without consulting a number of reference books. In order to illustrate, there follows a replica of the description as given for acetone:

ACETONUM

ACETONE

ACETON-DIMETHYL-KETONE

Acetone contains not less than 99% of $CH_3 \cdot CO \cdot CH_3$.

Description and physical properties—A transparent, colorless, mobile liquid, having a characteristic odor. It is inflammable. Acetone is miscible without cloudiness with water, alcohol, ether, chloroform, and most volatile oils.

Tests for identity—Specific gravity: about 0.790 at 25°C. It boils between 56° and 58°C., but volatilizes even at low temperatures. Add 1 cc. of sodium hydroxide T.S. to 1 cc. of an aqueous dilution of acetone (1 in 200), warm the mixture, and add a few cc. of iodine T.S.: a yellow precipitate of iodoform is formed at once. Mix 1 cc. of the same acetone dilution with 5 drops of sodium nitroprusside T.S. and 2 cc. of sodium hydroxide T.S., and add a slight excess of acetic acid: a deep red liquid is produced which develops a violet tint when diluted with several volumes of water.

Tests for purity—Acetone diluted with an equal volume of distilled water does not affect the color of blue or red litmus paper previously moistened with water.

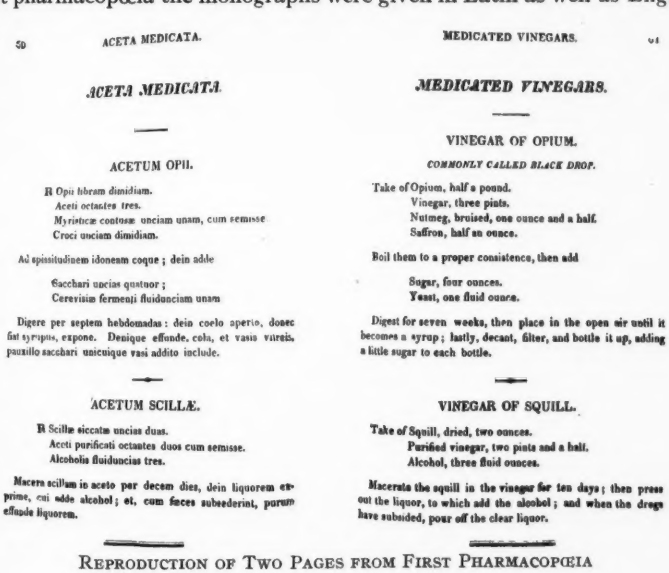
Evaporate 50 cc. of acetone in a dish on a water-bath, and dry to constant weight at 100°C.: the weight of the residue does not exceed 0.002 g. Mix 20 cc. of

acetone with 0.1 cc. of tenth-normal potassium permanganate in a clean, glass-stoppered bottle: the pink tint produced does not wholly disappear in less than fifteen minutes (empyreumatic substances).

Assay—Determine the exact weight of a glass-stoppered weighing bottle containing 15 cc. distilled water, add about 1 cc. of acetone, and again weigh accurately. Transfer the contents of bottle to a 1000-cc. graduated flask, rinse the weighing bottle with several portions of distilled water, and add the rinsings to the flask. Fill to the mark with distilled water, and mix thoroughly. Place 25 cc. of normal sodium hydroxide in a 250-cc. glass-stoppered flask, add exactly 25 cc. of the acetone solution and 35 cc. of tenth-normal iodine, with constant agitation of the flask, and allow the mixture to stand for fifteen minutes. Add 26 cc. of normal hydrochloric acid, and at once titrate the residual iodine with tenth-normal sodium thiosulfate, adding starch T.S. as indicator when the liquid is nearly decolorized. Conduct a blank test with the same quantities of the reagents, and subtract the quantity of tenth-normal iodine consumed in the blank test from that consumed in the assay. Each cc. of the difference, which represents the iodine consumed by the reaction with the acetone, corresponds to 0.0009677 g. of $CH_3 \cdot CO \cdot CH_3$.

Preserve in well-closed containers, in a cool place, remote from fire.

It may be observed that the old Latin name is still retained for the official designation, a principle which is adhered to throughout the book. In the first pharmacopœia the monographs were given in Latin as well as English.



50 ACETA MEDICATA.

ACETA MEDICATA.

ACETUM OPII.

℞ Opii libram dimidiam.
Aceti octantes tres.
Myristicæ contusæ unciam unam, cum semisse
Croci unciam dimidiam.

Ad spissitudinem idoneam coque; dein adde

Saccheri uncias quatuor;
Cerevisiæ fermenti fluiduncium unam

Digere per septem hebdomadas: dein cœlo aperto, donec fiat syrupus, expone. Denique effunde, cola, et vasis vitreis, pauxillo saccheri unicuique vasi addito include.

ACETUM SCILLÆ.

℞ Scillæ siccatæ uncias duas.
Aceti purificati octantes duos cum semisse.
Alcoholis fluiduncias tres.

Macera scillam in aceto per decem dies, dein liquorem exprime, cui adde alcohol; et, cum fæces subsederint, purum effunde liquorem.

MEDICATED VINEGARS. 51

MEDICATED VINEGARS.

VINEGAR OF OPIUM.

COMMONLY CALLED BLACK DROP.

Take of Opium, half a pound.
Vinegar, three pints.
Nutmeg, bruised, one ounce and a half.
Saffron, half an ounce.

Boil them to a proper consistence, then add

Sugar, four ounces.
Yeast, one fluid ounce.

Digest for seven weeks, then place in the open air until it becomes a syrup; lastly, decant, filter, and bottle it up, adding a little sugar to each bottle.

VINEGAR OF SQUILL.

Take of Squill, dried, two ounces.
Purified vinegar, two pints and a half.
Alcohol, three fluid ounces.

Macerate the squill in the vinegar for ten days; then press out the liquor, to which add the alcohol; and when the dregs have subsided, pour off the clear liquor.

REPRODUCTION OF TWO PAGES FROM FIRST PHARMACOPŒIA

This procedure was followed to avoid mistakes and permit general usage; however, the modern tendency is to disregard this old method.

Of particular interest to the analytical chemist are the descriptions of the general tests, processes, and apparatus to be found in the back of the Phar-

macopœia. Accurate and reliable descriptions for the carrying out of such tests as acid number, alcohol determination, arsenic tests, assays for acids and bases, boiling and distilling points, congealing points and electrolytic determination of copper, mercury, silver, zinc, heavy metals test, and a complete listing of qualitative identification tests for chemicals. The monograph on melting points is especially comprehensive and valuable as well as the monographs on optical rotation and refractive index.

Some three hundred of the most common reagents used in organic and inorganic chemistry are described and methods for their preparation are given. The monograph on volumetric solutions covers all the common solutions used in titration work with their methods of preparation and standardization.

Following this is given a list of all the official chemicals and reagents of definite composition with their atomic and molecular weights. This list is particularly valuable as a time saver. Such chemicals as calcium iodobehenate are listed with its formula $(C_{21}H_{42}ICO_2)_2Ca$; and molecular weight of 970.80. Likewise many of the hydrated salts with complex formulas and high molecular weights are given. Other tables and charts too numerous to mention may be found here in a concise form ready for practical usage. The man who is engaged in practical laboratory work, whether it be analytical or research, will find between the covers of this book a mass of information of unusual value.

American chemistry and medicine may well be proud of the United States Pharmacopœia for it is universally recognized as one of the outstanding books of its kind in the world. Translations are prepared in the Spanish for South American countries where it is generally accepted as an authoritative standard. Also the coöperation between the Revision Committee of the Pharmacopœial Convention and the International Conference for the Unification of Formulas for Patent Remedies, as well as coöperation in drawing up the International Protocol has been most outstanding.

In the field of biological chemistry the pharmacopœia also finds a definite place. Biological assays of those drugs or chemicals for which no chemical assay is known occupies a prominent place in this volume. This comparatively new field of bio-assays is receiving a great deal of attention from the revision committee and many noteworthy advances are being made.

At the present time the therapeutic usefulness of the drugs is not discussed in the Pharmacopœia but present indications are that in the near future these may be added to enhance its value. From a chemical standpoint such an addition would be of little value, of course, but the research worker in biology, pharmacology, pathology, bacteriology, and pharmaceutical and medicinal chemistry as well as the practicing physician and pharmacist would benefit greatly.

By way of introduction one might mention also some of the men who, while outstanding in the field of chemistry, gave a great deal of time and effort in behalf of the U. S. P. That grand old gentleman, Dr. Harvey Wylie, who did so much to bring scientific order out of selfish political chaos devoted much of his seemingly untiring energy toward making the Pharmacopœia an accurate and reliable standard. J. J. Abel, Frederick B. Power, Joseph P. Remington, H. C. Wood, and a score of others more prominent in medicine and pharmacy than chemistry, but who have contributed much to our scientific store of information, have seen fit to devote a great deal of their time and experience to revising the U. S. P. every decade.

To conclude, Dr. E. Fullerton Cook, chairman of the revision committee for the U. S. P. XI, has ably expressed the present status of our Pharmacopœia when he said:

> One hundred and ten years of experience, of earnest and honest planning for the welfare of this nation provide the background for the U. S. P. Happily the century has not produced an antiquarian or a degenerate but rather an aggressive, progressive, and modern guide to medicine and pharmacy, fully in keeping with the spirit of scientific progress of today.

The chemist who is keen enough to grasp the potentialities of a treatise such as the Pharmacopœia in an age when science is moving at such a break-neck speed, will find modern, accurate information that will broaden his field of endeavor, enlarge his possibilities, and help to bridge for him that ever-narrowing gap between medicine and chemistry.

Tantalum. The metal tantalum has now been brought out of the realm of mystery and is being produced commercially. It is too early to predict its full possibilities, but its unusual physical and chemical properties indicate many special applications.

Tantalum is about as hard as cold rolled steel. It is exceptionally ductile when cold worked and may be hammered, rolled, machined, drawn, spun, and punched into various forms; when annealed it will withstand considerable working. It is readily welded either to itself or to other metals. It is not affected by hydrochloric or nitric acids, by organic acids, or even by aqua regia.

Tantalum is not without its limitations, however. It is attacked by hydrofluoric acid, must not be heated in air and cannot be worked hot. It freely absorbs common gases such as hydrogen, oxygen, and nitrogen at moderately high temperatures, although these gases, once absorbed, may be driven out by heating the metal in a vacuum.

Tantalum can be obtained in sheet, tube, rod, and wire form. Its resistance to moist chlorine or bromine makes it valuable for the construction of plant equipment handling these gases. It is also of interest to manufacturers of dyestuffs and pure chemical reagents and replaces the more expensive platinum for laboratory ware for certain purposes. Tantalum agitators are useful where corrosion resistance and strength are required. Tantalum spinerets for the rayon industry are much less expensive than platinum-gold or palladium-gold alloy spinerets. Special high-pressure and vacuum equipment made of tantalum is now in service. Linings for autoclaves and acid towers are being made.—*Ind. Bull., Arthur D. Little, Inc.*

AN UNDERGRADUATE SEMINAR*

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At Howard College, for a number of years, seniors have been required to write theses for the bachelor's degree, and the seminar described in the present paper was instituted for the primary purpose of assisting the student in his thesis work. While research reports receive the major emphasis in the seminar throughout the session, two other types of reports have been worked in. The first of these is designed to strengthen and unify the four-year work in the department. The second type aims to help the student who desires graduate training.

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Theses and seminars are forms of mental discipline usually reserved for graduate students. In some institutions, however, seniors are required to write theses for the bachelor's degree. Such has been the situation at Howard College for a number of years, and it is the opinion of the administration that the thesis gives to the arts college a distinct place in the educational system of the country, for on the one hand it differentiates the curriculum of the college from that of the high school, and on the other hand it serves to introduce the student to research, the method of thought in the university. The question of giving this training to those who do not plan to enter a graduate school is one upon which something may be said on both sides. A problem open even more to discussion is the advisability of permitting the future graduate student to obtain his first contact with research from instructors whose major interests are not in productive scholarship.

The problem of the undergraduate thesis is beyond the scope of the present paper. We shall limit our discussion to a description of a seminar which was instituted in the department of chemistry three years ago with the primary purpose of assisting the student in his thesis work.

The seminar meets one hour a week throughout the year. Attendance is required from all seniors majoring in the department. Five semester hours credit is given for the thesis and seminar. During the opening meetings members of the staff present phases of their own research work. These reports are drawn up in sufficient detail to give the student an intimate picture of the real nature of research. Especial attention is called to such general problems as how to search the literature, how to make and file notes upon significant articles, how to keep an accurate laboratory record, and how to attack the numerous specific problems which arise in any type of research.

As soon as the students begin laboratory research on their problems the first part of each seminar is taken up with brief individual reports upon the progress made. These reports carry advantages to the individual

* Presented before the Division of Chemical Education at the 80th meeting of the American Chemical Society, Cincinnati, Ohio, Sept. 8–12, 1930.

and to the group. The individual profits not only from the regular check-up on his own work, but he has the opportunity to obtain suggestions from others toward the solution of some specific difficulty. The group benefits from the association with other problems, their difficulties, and how they are solved. At some seminar sessions the whole hour is spent in the discussion of the previous week's work.

While research reports receive the major emphasis throughout the year, we have been able, because of the limited number majoring in the department, to work in two other types of reports. The first of these is designed to strengthen and unify the four years work in the department. The second type aims to help the student who desires graduate training.

There is little need for putting forth an extra effort in a seminar to strengthen and unify the four-year course in the case of the superior student. This has been made apparent from oral examinations given to such students during the past four years at Howard College. These examinations have been held in connection with an honors course. The students whose grades were sufficiently high to enable them to qualify for the honors course have, with one or two exceptions, passed most creditable oral examinations of an hour's duration.

Although the superior student may show a comprehensive grasp of the subject matter of six to ten full-year courses in his major department, the situation is quite different with the average student. The meager store of knowledge retained by the latter a year or two after the completion of a course is often pitiful. This condition may be corrected in some measure by a review through seminar reports of the more important topics studied during the four years. One of the most effective methods of conducting this review is to request each student to prepare a list of the names of twenty-five or thirty men who have made significant contributions to the larger fields of chemistry. A list from the field of atomic structure, for example, might well include the names of Rutherford, J. J. Thomson, Aston, Fajans, Soddy, Crookes, Röntgen, Becquerel, Curie, Bragg, Guye, Zeeman, C. T. R. Wilson, Bohr, G. N. Lewis, Moseley, Kossel, Langmuir, Sommerfeld, Schrödinger, and de Broglie. Lists of nearly equal length may be prepared for such other divisions of physical chemistry as solutions, colloids, catalysis, and electrochemistry. With a little preparation the fields of general inorganic, analytical, organic, and industrial chemistry may be worked even more intensively. The actual method of conducting the review may vary from a formal report by a single student to an oral quiz session participated in by all. Interest in the latter may be heightened by having the staff members take their turn at identifying names submitted by the students. The tendency of such a contest, however, is to run toward the more obscure contributions, whereas the most profit will be derived from the consideration of the more fundamental discoveries.

A more rigorous method of testing the ability of the student to handle fundamental theoretical principles is through the solution of typical calculations selected from the several fields of study. The student who has given little evidence of enthusiasm for mathematical treatment in the regular course work may become interested in this general survey. Problems which he understood only imperfectly in a certain course he finds have been cleared up by knowledge gleaned from some other course pursued later. The student gains confidence with this increase in his ability to handle the ordinary mathematical operations of undergraduate chemistry.

The last type of seminar report we shall consider does not come last chronologically, for the student who desires to enter upon graduate study should give thought to the selection of a university before the middle of the senior year. This is of particular importance in the event the student has maintained his scholarship on a level from which he may reasonably expect to secure a graduate assistantship. Students in the upper twenty-five per cent of the senior classes at Howard in recent years have experienced little difficulty in obtaining assistantships from universities of recognized standing.

Two means are employed to acquaint the student with current research in American universities. One is through journal reports, and the other is by means of talks by members of the staff. The journal reports are conducted just as in the familiar journal clubs of a graduate school, except that the articles selected are from leading research men in this country. The volumes of the "Annual Survey of American Chemistry" supply abundant material for such seminar reports.

The remarks by the staff members are confined to institutions with which they are personally acquainted, and to individuals whose work they have followed with some persistence. In these talks the student finds crystallized the arguments, first suggested when he was a freshman, and often repeated thereafter, that the surest way to lay a broad and firm foundation for his professional career is through graduate study. Not every student will profit from a graduate course of study, but we try to eliminate most of those who would not in the twenty-five to thirty-five per cent of failures in the first-year professional course. The result of this emphasis upon further training is apparent in the fact that of the total number majoring in the department during the past six years, between forty-five and fifty per cent have entered graduate institutions. This result is made more significant by the location of the college in one of the strongest and most rapidly growing industrial centers in the south.

In conclusion, we have outlined a program which has proved each year more ambitious than we have been able to realize. We state frankly to the students at the very beginning, however, that a seminar is not so much a place where knowledge is gained as it is a meeting in which each individual

student is led to discover his own strength and weakness. We can do little more in a seminar than point to doors of opportunity through which the student will have to force his way by his own efforts. A seminar, graduate or undergraduate, which holds as its objectives the orientation of the student in his present location, and the pointing of the way into the future, has remained true to the basic meaning of the word seminar.

The Real Need of University Education. Though the trend of university education, on the whole, is toward sane and moral life, and though it can have no higher final end, it cannot pursue its result through any systematized machinery. "The rod behind the mirror," once the reliance of German households, has no place in the university. No system of rewards and punishments ever made men good or wise, and none is more futile than that of honors balanced against demerit marks. Enforced attendance at prayers or chapel or, for that matter, at anything else, fails to arouse the spiritual nature, and didactic teaching or paternal scolding are alike ineffective.

As love casts out fear, so enthusiasm casts out vulgarity—vice's initial step. The university man should rise above the cheap temptations which beset youth on every side, now ten-fold more numerous than before war raised the lid under which society formerly tried to confine vulgarity and folly. "War-time is the opportunity for fools," as Lord Courteney used to say. War's aftermath is their season for self-exploitation.

But the university man should resist all this. The foes he must engage are more subtle than those which center in jazz and bootlegging—as varied also as his own relations to society. The university should help him to meet them valiantly. This it can do through the contagion of personality, the inspiration of intellect, the arousing of enthusiasm for intensive work, a spirit of devotion and helpfulness toward others. As for the first, to turn our youth toward righteousness we must show them how righteousness looks when it is lived. As to the second, a great teacher always leaves a great mark on every student with whom he comes into real contact. As to the third, great investigators breed investigators; that such intellectual heredity exists among scholars is recognized by every serious worker. . . .

The scholar's life should have a moral purpose. His training is not merely a possession but a privilege carrying with it a duty to humanity. Give him a message to speak to other men and when he leaves your side you need fear for him not the world nor the flesh nor the devil.

Any university can exert a tremendous impulse for moral life, though only through the unflinching devotion of its members. This influence must be exerted spontaneously, even unconsciously, by men alien to all forms of vulgarity and vice and thoroughly imbued with the best in mind and morals.

Let me quote, in closing, from an address by William James at Stanford in 1906 on "The University's Spiritual Superstructure":

"The first unit of this superstructure must be a faculty of great men, at whatever cost, from every part of the world. If you have the geniuses, you can dispense with the organization. Spiritual life passes from man to man by contacts. Offer the opportunities, leave the student to his natural reaction. Geniuses are ferments. When they come together the effects are incalculable but pervasive and momentous."—By David Starr Jordan from "The American University System, Past and Present," part 3 of *The Trend of the American University*, Stanford University Press, 1929, via *J. Natl. Educ. Assoc.*

TEACHING HIGH-SCHOOL CHEMISTRY TEACHERS

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An actual workable outline on the subjects of valence and the writing of formulas and equations is herewith presented to aid beginning chemistry teachers.

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Occasionally a high-school graduate who has entered a college chemistry course, comes back and tells his high-school instructor, with some degree of satisfaction, that the college instructor told the students to forget all their high-school chemistry before attempting to start their college work. The high-school teacher has heard this often enough to be able to keep quite unperturbed. He agrees, and tells his former disciple to adopt without question the ways of the new master.

There are certainly essential differences in methods of presentation in secondary-school and college chemistry. The difference in the subject matter necessitates them. Few modern high schools teach college-preparatory chemistry exclusively. There are too many household, civic, and industrial applications that demand attention. Chemical theory is not the thing of primary interest to large numbers of present-day secondary-school students. Yet valence must be taught, and equations must be balanced, and problems must be solved.

Now, what does the college graduate, who starts his practice teaching in high-school chemistry, do? Is he able to start at the level of the high-school child? Seldom. That college graduate has to forget much of his college chemistry if he is to be a successful high-school teacher. Few graduates are able to tackle adequately the problem of teaching valence, formula writing, and equation balancing for the first few years. To aid them, the writer prepared the following outline, for what it may be worth, either to beginning high-school teachers, or to those who face the problem of teaching practice teachers. The new teacher could have enough copies of this outline mimeographed to give every pupil one.

I. How are acids and salts named?

Kind of acid:	No. of elements:	Name includes:	Ends in:	For example:	Salt derived from this acid:
(A) Binary	.....	.....	.....	.....	.....
(B) Ternary	.....	.....	(1).....	.....	.....
	(If one less O atom:)		(2).....	.....	.....

II. What are the valences of important elements and radicals?

(A) Those having valence of +1:

Name:	Symbol:
(1).....	.....
(2).....	.....
(3).....	.....

(B) Those with valence of −1:

Name:	Symbol:
(1).....	.....
(2).....	.....
(3).....	.....

(4)..... .....
(5)..... .....
(6).....(ous) .....
(7).....(ous) .....

(C) Those having valence of +3:
(1).....(ic) .....
(2)..... .....

(E) Most metals used in high-school chemistry that are not listed above, have valence of +2.

(4)..... .....
(5).....ate, and.....ite. .....
(6)..... ClO_3
(7)..... $C_2H_3O_2$

(D) Those with valence of −3:
(1).....ate. .....
(2).....ite. .....

(F) Most non-metals and acid radicals used in high-school chemistry, not listed above, have valence of −2.

III. How are formulas of chemical compounds written?

For example, using the following rules, and applying what you know about valences, write formulas for:

Rules:	Silver nitrate:	Sodium sulfate:	Aluminum hydroxide:
(1) Determine the valence of metal, +:	.....	.....	.....
(2) Determine the valence of non-metal, −:	.....	.....	.....
(3) Are valences of + and − same, or not?	.....	.....	.....
(4) If same, write symbol of each, once:	.....	.....	.....
(5) If not same, take each element or radical as many times as the valence of the *other* one:	.....	.....	.....
(6) If a radical (compound) is taken more than once, put parentheses ( ) around it, and write number outside:	.....	.....	.....

If you think you know how to write formulas, fill these in:

	Chloride	Hydroxide	Sulfate	Carbonate	Phosphate
Sodium	(1)	(2)	(3)	(4)	(5) .....
Ammonium	(6)	(7)	(8)	(9)	(10).....
Calcium	(11).....	(12).....	(13).....	(14).....	(15).....
Barium	(16).....	(17).....	(18).....	(19).....	(20).....
Aluminum	(21).....	(22).....	(23).....	(24).....	(25).....

Allowing 4 points for each correct one:.....%.

IV. Four chief types of chemical reactions are:

(1).....as:.....
(2).....as:.....
(3).....

(*a*) A metal displaces another in a compound, if the element by itself is higher in the electrochemical series than the element in the compound is. As:.....

(*b*) A non-metal displaces another in a compound, if it is above that other one in the following series: Chlorine
Bromine
Iodine As:.....

(4).....which go to completion due to:
(*a*).....as:.....
(*b*).....as:.....
and (*c*).....as:.....

V. What is neutralization?

An acid, which always starts with...., plus a base, which always ends with.... react to yield...., and a..... as:

VI. What are the solubility rules?

With reference to water:

(1) All....., ..., and.....compounds are soluble.
(2) All.....s, ...s, and .....s are soluble.
(3) All chlorides are soluble, except:....., ...and.....
(4) All sulfates are soluble, except:....., ...and.....
(5) .....s, ...s and.....s are generally insoluble, except:
.....

Coal Mine Explosions Preventable Disasters. Great coal mine explosions are preventable disasters, because they probably need never occur if every mine were to make use of the precautionary measures, especially rock dusting, already worked out by mining engineers, it is believed by George S. Rice, chairman of the Mine Safety Board of the U. S. Bureau of Mines.

Coal when in the form of dust suspended in air is explosive; and in coal mines, as in blasting powder plants, every precaution is necessary in order to prevent explosions and fire. When the mines are working to capacity, and coal dust becomes dry from the entering cool dry air, operators should be particularly vigilant and cautious.

Government recommendations and state regulations have placed in the hands of mine operators information regarding the most effective methods of guarding against disasters. All open lights or other sources of ignition, whether from lamps, open sparking machinery, or flaming explosives, should be avoided.

Another approach to the problem, besides the elimination of sources of ignition, is the thorough ventilation of the mine and the treating of the explosive coal dust by what is known to mining engineers as "rock dusting."

Rock dusting is a recently adopted method of making the coal dust non-explosive. Finely pulverized inert material is spread in the mine and mixed with the coal dust so as to dilute it. If more than 65 per cent of the mine dust is incombustible, the mixture cannot explode in a dust cloud. Every portion of the mine must be thoroughly and constantly rock dusted for complete safety. Just as one match in a powder magazine brings disaster, so one explosive area in a mine may cause the loss of miners and mine.

The safety division of the U. S. Bureau of Mines has found that notwithstanding the fact that mining engineers generally recognize the fact that widespread explosions can be almost absolutely prevented in coal mines by this method, rock dusting is not yet used in the majority of our coal mines. Despite the fact that thorough rock dusting would cost less than one cent per ton of coal, only a small percentage of the mines in this country are thoroughly rock dusted.

It is estimated that the cost of equipping mines with the most modern and best safety measures, and of maintaining them in working condition would add less than 10 cents per ton to the cost of coal. Yet a major explosion may cost as much as a million dollars.—*Science Service*

Poland to Protect Civilians against Gas. Poland is undertaking to protect its civilian population against the often-painted horrors of wholesale gassing expected if a "next war" ever comes, the International Red Cross has learned. A corps of men trained in clearing up gas-drenched areas is being formed, gas masks for civilians are to be provided and the people to be instructed in their use, and civilians are to be trained to supplement the work of the regular corps of anti-gas experts. Peace-time uses for war gases are being sought, especially in agriculture.—*Science Service*

DIVISION OF LABOR

MAX SMALL, NEW HAVEN HIGH SCHOOL, NEW HAVEN, CONNECTICUT

"Division of Labor" raises and discusses the question as to what part of the teaching job should be done by the teacher and what part by the textbook. The advantages of a definite decision on this question are discussed and it is suggested as a topic for serious consideration by chemistry teachers. The author gives his own opinion suggesting that the real teaching be done by the teacher; that the textbook serve the two-fold purpose of (1) giving a clear-cut resumé of minimum essentials and (2) providing a series of drill exercises and questions; that collateral reading be used to develop each student along his own line of interest. Possible objections to the plan suggested are also discussed.

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What is the relationship that should exist in our academic triangle—textbook, teacher, pupil? Too little thought has been given to a suitable statement of this theorem and to its satisfactory solution. Like the alchemists in their independent searches for the philosopher's stone, writers of textbooks and teachers have sought the key to successful performance of educational transmutations.

And yet, questions of paramount importance have neither been raised nor settled. If we are to attain our ends most effectively and economically from the point of view of time and effort on the part of teacher and pupil, the question of the proper division of labor between textbook, teacher, and pupil should be attacked.

What is the function of the textbook in chemistry? Is it an instrument which, placed in the hands of the uninitiated, will develop and maintain interests which will lead him to the attainment of certain skills through the study of its explanations and the execution of its exercises? What is the function of the chemistry teacher? Is it to make assignments in the textbook and hear recitations, to make demonstrations and give lectures, to supervise laboratory work, and last but not least, to measure and pass judgment on the satisfactory attainment of skills?

It seems to me that this question is fundamental. Too many poor results in our schools are due to this indefinite division of labor. Each teacher assigns a different job to the textbook, depending on his personal notion of its function. The poor book, driven by the author's desire to please and by economic pressure, tries to serve all of these masters. It undertakes tasks far beyond its powers and is forced to use so many words that it becomes unwieldy, although the average teacher does not notice it. For he understands it perfectly. Written by an authority and having the prestige of the printed page behind it, it is a thing sacred and its precepts must be carried out. And so the teacher becomes a task maker and a tester: he assigns lessons and hears recitations. To those who succeed in carrying through his program he metes out credit; to the others—ex-

hortation, invective, and punishment. His lot is not a happy one, nor is that of his pupils.

What is the solution? The problem of teaching effectively and economically involves factors which are so many and so varied, that a general solution cannot and need not be given. But it would help much if the question of the proper division of labor between teacher and text were settled with some degree of definiteness. It is hoped that this paper will stimulate consideration and discussion of this topic among teachers. The JOURNAL OF CHEMICAL EDUCATION might well solicit opinions on this question and appoint a committee to tabulate the results.

I venture the opinion formed as a result of my own studies. I would liken the pupil to the rough stone (and there are many varieties), the teacher to the sculptor, the textbook to the various tools and drills which are needed for the completion of the statue. The tools must be wieldy, pointed, and effective, each in carrying out its particular function. It is doubtful whether a machine will ever be invented which will take the place of the artist's touch.

The function of the teacher is to teach. He must develop a nice blending of classroom procedures: motivation, direct tuition, demonstration, drill, laboratory work, collateral reading, and oral and written testing.

The function of the textbook is two-fold. First, it presents concisely, though completely, the essentials, the *sine qua non*, of the currently accepted high-school chemistry course. Tabular form is used when possible. It need not be *belles lettres*. It is thoroughly objective. Its only embellishments are pictures of those who have made chemical history and diagrams pertinent to the work, such as diagrams of laboratory preparations and commercial processes. It contains what we, as students, used to put down or rather what we should have put down in our lecture notes. It recalls in no uncertain terms to the student for home deliberation what the teacher has taught by precept and experiment.

Secondly, the textbook must contain ample drill in those skills which can be perfected only by repeated use, such as the writing of formulas, equations, and chemical arithmetic. It should also contain a sufficient number of questions which would lead the student to think along the lines of chemistry and serve as a basis for profitable class discussion after sufficient home deliberation. In this way the time required for making up and giving out assignments will be reduced to a minimum.

It may be objected that a textbook of this type will deprive the student of the experience of learning from the printed page, since the teaching is done by the instructor and the book is merely a resumé and assignment book. On the contrary, the procedure outlined above should effect a sufficient saving of time so that the student will be enabled to do considerable reading of chemical literature, in the form of collateral reading on

topics in which he may be interested. Under our present plan, or lack of plan, the student is so weighed down by his textbook work, that he has neither the time nor the inclination to do additional reading. And thus he loses the opportunity of becoming acquainted with a vast and useful branch of chemical literature.

Given such a textbook, the teaching of chemistry becomes considerably simplified for both teacher and pupil. Let us assume that the teacher wishes to present oxygen. Having created a desire, or at least a willingness or inclination, on the part of his pupils to learn about oxygen, he proceeds to a demonstration or a laboratory exercise on the subject. His home assignment in the textbook for the next day is a definite contract between teacher and pupil. It is presented in simple, straightforward, and unmistakable language. An exercise is included which leads the pupil to the use of the information given by teacher and book and to think along the lines of chemistry. When the teacher hears the next recitation, he knows that the assignment was definite and that he may expect specific answers. Here and there, the teacher suggests additional topics for further study. Student *A* is struck by the teacher's hint that phlogiston proved a stumbling block to the progress of chemical science and believes that history should teach us to avoid mistakes in the future: he offers to make a further study of phlogiston. Student *B* has become interested in this man Lavoisier who lived and died during the French Revolution and who is called the father of modern chemistry. Student *C* is utilitarian and wants to learn exactly how oxygen is gotten from the air for commercial application. *D* decides to make an exhaustive study of the uses of oxygen in obtaining high temperatures. A great many other topics may be suggested and used. The student makes an intensive study of the topic which he chose and submits his results to the instructor in writing. The teacher uses these reports as he sees fit. He may have them presented to the class. He may place them on reference for other students to read. He may have them printed in the student publication. In this way the willing student begins the type of research which he will have to do when he enters his vocation. He becomes familiar with reference books on chemistry; he learns to use the printed page and to organize his results.

It may also be objected that the procedure outlined above is inadequate for the new or inexperienced teacher of chemistry. It is no more so than the present method which merely obscures his difficulties and places an undue burden on the pupil. For the new teacher, we need less literature on education in general and more on the specific teaching of chemistry.

A textbook of the type described may be published at a much reduced price. The saving so effected may be used in many ways. Some of the money saved may be used for the building up of a satisfactory chemistry library. New type tests are rapidly being accepted by progressive teachers

as essential teaching devices. Unfortunately, the expense involved in their purchase has proved a serious handicap to their use. The saving on the price of textbooks may be diverted for this useful purpose.

This paper must not be construed as an attack on our textbook writers who have labored honestly and earnestly for the improvement of chemistry teaching. It is hoped, however, that teachers will cast aside their traditional notions regarding chemistry textbooks and approach in the same scientific spirit as they do their chemical researches this question: what is the function of the teacher and what is the function of the textbook?

Poisonous Principle of Insect Powder Traced. The poisonous principle of old-fashioned insect powder has been traced to its lair by C. B. Gnadinger and C. S. Corl, research chemists of Minneapolis. The powerful poison of the material has been located largely in the achenes, or fuzzy seeds of the Pyrethrum plant, from which it is prepared.

Pyrethrum, a variety of chrysanthemum, has been used to abate insect nuisances for generations. The flowers, and even leaflets and stems of the particular species, are commonly ground into a fine powder which is extremely toxic to insects but harmless to man.

Some time ago the noted Swiss chemist Staudinger solved the mystery of the chemical formula of "pyrethrin," the potent oil which gives the value to the insect powder. The oil is actually a mixture of two similar but complicated substances containing only carbon, hydrogen, and oxygen, innocent elements when in simple relations. Being an oil, it may be diluted in gasoline or like solvent and used in sprays where dusting powders are undesirable.

The two Minneapolis chemists have now discovered a method of chemical analysis whereby one may quickly tell which plants, and which parts of the plants, contain the poisonous principle. Armed with the new method they have upset several long-standing beliefs in the insect-powder business. Japanese pyrethrum has been found to be just twice as potent as the classic and more expensive Dalmatian powder. Also the mature flowers are more valuable than the unopened or half-opened buds, which the trade prizes and holds at higher prices. Stems and florets have relatively little value compared to the achenes.

The extreme toxicity of pyrethrin was shown in the Minnesota experiments by a test on cockroaches. A solution of one part of the oil in 80,000 of water effected a complete slaughter of a colony of the pests submitted to the test.

The perfecting of these chemical experiments opens the door to most promising research in plant breeding. Just as the sugar content of beets was raised in cultivation, so may it be possible to increase the pyrethrin content of chrysanthemums. At present only about one-half to three-quarters of one per cent of the powder is actual poison. Modern selection methods as practiced by plant breeders would probably lead to great increase in efficiency in agricultural pest control. It is also considered possible that the essential principle itself may be made synthetically if the demand should be sufficient.—*Science Service*

I never care if others pluck out feathers which I intended to drop at the next moulting season; only those who cannot grow new plumage need worry about such happenings.—LIEBIG

AN EXPERIMENT ON THE USE OF JOURNAL ARTICLES IN TEACHING ELEMENTARY COLLEGE CHEMISTRY*

HOYT C. GRAHAM, NEW MEXICO STATE TEACHERS' COLLEGE, SILVER CITY, NEW MEXICO

An effort to make elementary college chemistry more practical and interesting for non-chemistry majors has been made at the New Mexico State Teachers' College. The fundamentals of chemistry were taught in close relation to the students' environment. This was accomplished by teaching more subject matter from science journals and popular magazines.

These journal and magazine articles stimulated interest and motivated the class to study fundamental laws and theories. As a result of this motivation previously indifferent students took an interest in the work and test grades showed that the quality of the work was as good as for previous classes taught in the traditional way.

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At the present time much attention is being given to revising elementary college chemistry in order to make it more practical for non-chemistry majors. This has been a major problem in the chemistry department of the New Mexico State Teachers' College. The majority of our students who enrol for elementary chemistry do not expect to pursue the subject farther Too many of them enrol merely on account of the nine-hour laboratory science requirement for graduation. As a rule this type of student has shown little interest in the subject and has often failed to complete the year's course.

Two years ago the author undertook to work out some method of conducting elementary chemistry by which the interest and coöperation of the non-majors could be obtained and the number of withdrawals and failures decreased without lowering the standard of the work. Most excellent results were obtained after the middle of last school year when elementary chemistry was converted into what might be called a course in environmental chemistry. The term environmental chemistry seems appropriate since the students were permitted much freedom in choosing the subjects or topics for study and since fundamentals and theories were always related to the students' environment.

The subject matter for the course was taken largely from science journals and magazines, such as, JOURNAL OF CHEMICAL EDUCATION, *School Science and Mathematics*, *Saturday Evening Post*, *World's Work*, etc. The author has been led to believe that if the excellent material contained in the science journals, popular magazines, and newspapers is studied in the light of the theories and fundamentals in the textbooks the problem of creating interest and enthusiasm in indifferent students will tend to disappear. After all, the subjects which are discussed in our popular magazines and newspapers are subjects of general interest. These are

* Read before the Division of Chemical Education at the 80th meeting of the American Chemical Society, Cincinnati, Ohio, Sept. 10, 1930.

the subjects on which our students will need to converse after leaving college.

In our work the articles were not read as outside material and the idea was not to supplement the text. Both journal or magazine and textbook materials were taught together. The one was considered as important as the other. The fundamental laws and theories were stressed just as much as when the text was used more nearly alone; however, more stress was placed upon the importance of these laws and theories as means of explaining phenomena with which the students were already somewhat familiar. This connected the fundamentals of chemistry with the students' environment. They learned principles and theories as a means to an end rather than as ends in themselves.

In order to obtain suitable journal and magazine material a card index or reference was made to all articles which promised to be useful, contained in every volume of four journals in our library. Many references to isolated articles in various magazines were made. These cards were filed according to source or subject.

Our topics were studied as nearly as possible according to a unit system. An example will be given from the unit on metals.

A certain amount of time was alloted to the general topic of metals. Before this time all card references to metals were taken from the files, the articles were read rapidly by the instructor and a few notes on each article were recorded on the cards.

During class periods the instructor encouraged general discussions on any topics dealing with metals. He attempted to direct the discussion toward some topic on which he desired to make an assignment. The instructor's purpose was to motivate the class. When the entire class became sufficiently interested in some discussion involving points not covered in the day's assignment a future assignment was immediately made from the card references. By this method the students felt that they were studying the things that they were interested in and wanted to study. They felt that the chemistry course was for their benefit and that the final goal was not the mere completion of a certain text or outline. They were at liberty to pursue their own interests and solve their own problems.

In studying the unit on metals no attempt was made to follow the order of the text. When the class became interested in aluminum we studied aluminum. Two articles on this metal were assigned in addition to the chapter in the text. The articles added color and romance to the subject of aluminum. The contribution of Charles Hall was more fully appreciated after studying a four-page article on the present-day uses of aluminum.

Let us consider a second example. While studying the inert gases two articles were assigned in addition to that contained in the text. One of these articles was in the *Popular Science Monthly* and the other in the

Saturday Evening Post. The class as a whole became interested in a journal topic dealing with the application of helium to deep-sea diving as a means of preventing the "bends." They asked for more information on the "bends." An assignment dealing with the use of compressed air in deep-sea diving was made from the *World's Work.* Their interest in deep-sea diving led to a general review of gas laws and gas solubilities. The interest then turned to the inert nature of the gases and led to the study of atomic structure.

The above examples show how these articles serve as a means of motivating the study of laws and theories.

The author has seen previously indifferent students study with enthusiasm a theory which offered the best explanation of some phenomenon with which they were already more or less familiar but which they had not been able to understand on account of their limited experience.

The opinion of the author is that we do not need to worry about changing the kind of chemistry we teach. We must continue to teach fundamentals with as much force as ever but these fundamentals must be closely related to the students' environment.

The question of measurable results will naturally arise. Test marks indicated that these students knew as much about the fundamentals of chemistry as members of previous classes which were taught in the traditional way. The author feels that the results of tests, and improved interest and coöperation of the class were sufficient to recommend the method. The author also feels that it is the duty of science courses to introduce college students to popular science literature* and that this was successfully accomplished.

* In connection with The Chemistry Student section of the JOURNAL OF CHEMICAL EDUCATION from September, 1929, through June, 1930, abstracts of articles from *Scientific American, Popular Science Monthly, Science and Invention,* and *Popular Mechanics* were published. A subject index of these abstracts may be found on pages 3093–101 of the December, 1930, JOURNAL. This abstract work is now being continued in *The Chemistry Leaflet,* the student supplement of the JOURNAL OF CHEMICAL EDUCATION.

Ink for Treatment of Burns Has Scientific Basis. For generations ink has been a successful household remedy in the Philippines for the treatment of burns, Dr. C. A. Stammel, Captain, M. C., U. S. Army, has reported from Zambeanga, P. I. The surprising thing is that a scientific basis for the treatment exists, although it has only just been revealed.

Most black inks are simply weak solutions of an iron and tannic acid compound. Dr. Stammel pointed out, and scientists have recently discovered that tannic acid itself is an efficient method of treating burns. Thus the Filipinos' confidence in this remedy of their grandmothers has been justified both by experience and by scientific research.—*Science Service*

CARD INDEX FOR THE JOURNAL OF CHEMICAL EDUCATION

HARRY L. ELDER, SWISSVALE HIGH SCHOOL, SWISSVALE, PENNSYLVANIA

This article describes a practical, up-to-the-minute index for persons using the JOURNAL OF CHEMICAL EDUCATION *frequently as a reference. Although very complete, the index is inexpensive and is very flexible, lending itself well to almost any type of indexing required. Ordinarily 3" × 5" file cards which may be typed, hand-printed or written are used. The type of holder used depends entirely upon the number of cards in the index and of course can be changed to suit the individual taste and pocketbook.*

. . . . . .

Having found a wide variety of uses for the JOURNAL OF CHEMICAL EDUCATION in my science classes, I felt the need of some kind of system whereby the work of looking up articles on various subjects might be lightened. Of course the yearly index was a great help but often the need of a monthly index made itself evident. The following system was evolved and is being passed on for whatever value it may be to others who use THIS JOURNAL constantly.

The first item to be considered was expense, and the method used is very inexpensive since the index consists of ordinary 3" × 5" file cards. Most of these are ruled on one side only but may be obtained with ruling on both sides. The type of holder to be used for these cards is governed largely by the number of cards. A very satisfactory file with index and capacity of three hundred cards may be purchased for about fifty cents.

The second point to be considered is ease of handling and flexibility, and this method has both of these qualities. The cards may be typed although this is a rather tedious task for any one, even an expert typist. Hand-printed or hand-written cards serve the purpose equally as well as the typewritten ones and can be handled more rapidly.

The important part of the index is the number and names of the divisions to be made. The fewer in number the sections, the more rapidly the magazines can be indexed. However, the number of sections should be great enough to include all types of articles with a minimum of overlapping. Those who are interested in certain phases only can use the names of these phases as division titles. Thus persons interested in physical chemistry only may use this as the main division and include such subdivisions as he may require. Therefore, the number and name of divisions may vary with the individual.

Being interested in all types of articles, I have included in my index titles which include all articles. The following list will give an idea of the completeness and variety of general indexing. Subdivisions may be inserted as desired.

Index Divisions

Agriculture
Alloys
Aluminum
American Institute of Chemists
Ammonia
Ammonium Compounds
Analysis
Aniline
Atmosphere
Beryllium
Bibliography
Biographical and Historical
Biological Chemistry
Boron
Carbon Compounds
Chemistry Clubs
Chemical Engineering
Chemical Industry
Chemical Profession
Chemical Warfare
China
Chlorine
Chromium
Citrus
Coal and Coal Tar
Colloids
Commercial
Copper
Corn
Corrosion
Dental
Diamond
Drugs
Education
Electrochemistry
Elementary (High-School) Chemistry
Enrichment of Life
Enzymes
Equipment
Europe
Explosives
Foods
Fuels
General (College) Chemistry
General Science
Health
Helium
Hydrogen Ion
Iodine
Lead
Leather
Legal
Light
Linseed Oil
Memorials
Microscopy
Nitrogen
Organic Chemistry
Oxygen
Paint
Phosphates
Photography
Physical Chemistry
Plants, Cement
Potassium
Preservatives
Refrigeration
Research
Resins
Rubber
Starch
Structure of Matter
Sulfur
Tantalum
Textiles
Tin
Vegetable Oils
Vitamins
Water
Wood

In making this index the division title was printed at the top with titles and dates of articles under this heading written in below. The number of articles to be listed on a single card will depend upon the amount of information which the individual wishes to file concerning each article. For my purposes the title and date was sufficient and that is all that has been listed, although author names might well have been inserted if desired. The following example will make clear the system which the writer has used.

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Brilliant Green Hailed as Most Potent Germ-Killer. Wounds in surgical operations may soon be sewed with bright green catgut affording to patients the greatest possible protection against infection, according to reports to the American Medical Association from Odessa, where Dr. S. Baccal has been experimenting with powerful antiseptics.

Dr. Baccal covered the lips of a wound with brilliant green, an aniline dyestuff, and the wound remained sterile during a period of seven days after the operation and it was impossible to obtain germ colonies from samples taken from the wound. Brilliant green kills all bacteria promptly, in smaller amounts and in more dilute solutions than any of the antiseptics known previously. It is not irritating; it can be applied to mucous membranes, it can be even placed in the eye. In the surgical clinic of Odessa it is now exclusively used for washing the surgeon's hands before operations, because it never leads to infections.

Dr. Baccal also found that the saturation of silkworm catgut with alcohol and brilliant green did not make this suture-material less soft, elastic, or pliable, and at the same time increased its safety causing no suppuration whatever.

This brilliant stuff has only one defect, it stains the hands of the surgeon a bright green which cannot be washed away for several days. Dr. Baccal is therefore anxious to find a formula for a bleach which will remove the color.—*Science Service*

Engineer Shows Which Foods Are Hardest to Freeze. Some foods freeze more readily than others, housewives with mechanical refrigerators have learned when they put the eggs or the apples too near the icing unit and returned a few hours later to find them as hard as rocks.

Engineers who design refrigerators and who quick-freeze foods to the solid state to be shipped and sold in small packages have also learned just how much easier it is to freeze one food than another. They have found the amount of heat that must be taken from a food in order to freeze it. A list of common foods and this value of heat, called the latent heat of fusion, is contained in a report made by A. H. Cooper to the American Society of Refrigerating Engineers.

Water is hardest to freeze, it being necessary to take 143.4 British Thermal Units of heat from a pound of water at 32 degrees Fahrenheit to change it to ice at the same temperature. Ranging down from 135 to 107 B. T. U.'s are lettuce, strawberries, onions, milk, apples, green beans, Irish potatoes, grapes, eggs, beef, and sweet potatoes.

For all practical purposes, Mr. Cooper states, the latent heat of the food can be found by multiplying the percentage of water in the food by 143.4, the latent heat of fusion of the water in the food. Thus less heat has to be taken from foods that contain little water, and it is easier to freeze them than to freeze foods containing much water. In this group are pork, cheese, bacon, and butter.—*Science Service*

AN EXPERIMENT ON REFRACTIVE INDEX FOR THE COURSE IN PHYSICAL CHEMISTRY

CREIG S. HOYT, GROVE CITY COLLEGE, GROVE CITY, PENNSYLVANIA

The determination of the refractive index of organic liquids by the use of the Abbé refractometer and the computation of molecular refractions constitutes a particularly effective application of physical chemistry to the study of organic structure. A list of liquids illustrating a wide range of structures with a minimum number of samples includes: n-propyl bromide, i-propyl bromide, bromoform, ethyl formate, n-butyraldehyde, ethylene chloride, allyl bromide, benzene, iodobenzene, alpha-bromnaphthalene, and cyclohexane.

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Nearly all manuals of experiments for the physical chemistry laboratory contain one on the determination of the refractive index of liquids, using the Abbé refractometer. The data of this experiment afford an excellent demonstration of the relationship between a physical property and the structure of organic compounds. The following selection of samples, which has been in use in the author's course for ten years, was devised to give the widest range of indices and of structures with the minimum number of samples. The liquids used were obtained from the Eastman Kodak Company and were not further purified. The measurements require about two and one-half hours for an inexperienced operator.

From the indexes as determined, the student computes the molecular refraction and compares his result with the sum of the atomic refractions, using the values given by Brühl. The densities may be determined as a part of the experiment, or, if the time is limited, the values may be furnished.

From this comparison of determined and computed refractions several important conclusions are drawn. The *n*-propyl and *i*-propyl bromides differ both in refractive index and in density and yet the molecular refraction is the same since there are the same number of atoms and the same number of bonds. The refraction of ethyl formate can only be obtained by the assumption that one oxygen is doubly bonded to a single carbon atom, while the other is bonded to two carbons as in ethers; a characteristic of esters. *n*-Butyraldehyde gives evidence of the doubly bonded oxygen typical of aldehydes. Allyl bromide affords an example of a double bond between carbon atoms in an aliphatic compound. The three double bonds of the Kekulé ring structure of benzene are required to equal the molecular refraction. The uncertainty regarding the nature of the double bonds in condensed benzene nuclei is shown by the fact that six double bonds are required to equal the molecular refraction of alpha-bromnaphthalene while only five are shown in the conventional formula. The lack of double bonds in the hydrocyclic compounds is shown in the

refraction of cyclohexane. The whole experiment demonstrates conclusively the relation between chemical constitution and refraction.

The data are from the work of a single operator and illustrate the degree of accuracy possible.

Liquid	*Refractive Index at 20°C.*	*Density at 20°C.*
n-Propyl bromide	1.4330	1.353
i-Propyl bromide	1.4234	1.314
Bromoform	1.5950	2.819
Ethyl formate	1.3625	0.917
n-Butyraldehyde	1.3843	0.817
Ethylene chloride	1.4440	1.252
Allyl bromide	1.4675	1.436
Benzene	1.5007	0.879
Iodo-benzene	1.6120	1.782
Alpha-bromnaphthalene	1.6556	1.487
Cyclohexane	1.4250	0.779

Specific Refraction $r = \frac{1}{d}\frac{n^2-1}{n^2+2}$	*Molecular Weight M*	*Molecular Refraction Mr*	*Sum of Atomic Refractions*
0.1921	122.99	23.608	23.787
0.1939	122.99	23.842	23.787
0.1205	252.90	30.483	30.333
0.2421	74.07	17.931	17.776
0.2864	72.08	20.638	20.699
0.2023	98.94	20.991	21.202
0.1933	120.98	23.399	23.392
0.3343	78.08	26.157	26.433
0.1948	203.99	39.797	39.502
0.2468	207.07	51.140	49.829
0.3290	84.13	27.613	27.618

Since the specific refraction of a liquid mixture is a linear function of its percentage composition, the refractometer may be employed for the analysis of such mixtures. The method is particularly useful for the analysis of the two phases obtained in the distillation of binary liquid mixtures. The present experiment serves a useful purpose in preparing the student for such applications.

Iodine Found Useful as Tobacco Fertilizer. Iodine, which has figured largely as "good medicine" for man and beast during the past few years, now assumes a similar rôle for plants. Investigations by the bureau of plant industry of the U. S. Department of Agriculture have shown that a small amount of iodine added to the soil produces a better growth of tobacco and an improvement in its quality. But if the desirable quantity is exceeded the effects are injurious, manifesting themselves especially in abnormal thickening of the leaf, off colors, poor keeping qualities, and unsatisfactory burning.—*Science Service*

THE DETERMINATION OF THE VAPOR PRESSURE OF GASOLINE

H. J. TORMEY, ST. BONAVENTURE COLLEGE, ST. BONAVENTURE, NEW YORK

A diagram and a description of the use of the Robinson vapor-pressure apparatus in determining the vapor pressure of gasoline are included.

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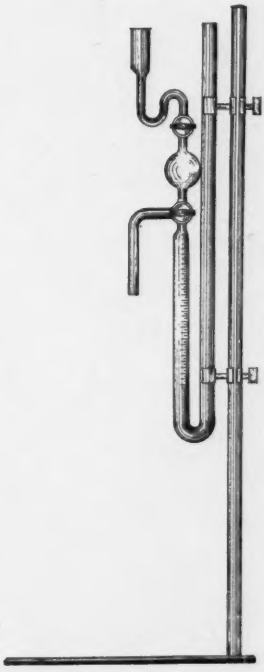
Since a determination of the vapor pressure of gasoline at various temperatures furnishes data of fundamental importance in the evaluation of gasoline as motor fuel, a description of the Robinson vapor-pressure apparatus, designed for this purpose, may be of interest.

A diagram of the apparatus and the procedure employed in making a vapor pressure determination, are given below.



Directions for Using the Robinson Vapor-Pressure Apparatus

Dry apparatus thoroughly by blowing air through it.

Close all the stopcocks, including the pinchcock on the rubber tubing.

Immerse the entire apparatus in water heated to the desired temperature. Immerse the apparatus so that the bulb between the two stopcocks is completely covered but so that the filling cup at the top projects above the water level. The end of the rubber tubing should also be kept out of the water.

Allow at least five minutes to elapse so that the apparatus will acquire the temperature of the water-bath.

Then open the upper stopcock to allow the air in the bulb to acquire atmospheric pressure.

Close upper stopcock.

Open the lower two-way stopcock and the pinchcock on the rubber tubing.

Introduce the gasoline to be tested into the long leg of the U-tube until the air in the U-tube is displaced by the gasoline which then begins to pass out through the rubber tubing.

Close the lower two-way cock and the pinchcock.

Withdraw some of the gasoline from the long leg of the U-tube by means of the pipet furnished. A sufficient quantity should be removed to form a vapor space between the lower cock and the level of gasoline in the short

leg of the U-tube. This procedure creates a slight suction on the bulb when the lower cock is opened.

Introduce some of the gasoline into the filling cup at top, the air being displaced by shaking and tilting the apparatus.

Open the lower two-way cock so that the bulb is in connection with the short leg of the U-tube.

Open the upper cock and allow small portions of the gasoline to enter the bulb so as to saturate the air in the bulb with gasoline vapor. *NEVER allow the filling cup to become entirely empty of gasoline because excess air would then enter the bulb.*

Continue to pour gasoline into the filling cup and to allow small portions to enter the bulb until the air is saturated. When this point is reached, further addition of gasoline will not change the difference in level of the two legs of the U-tube. During this procedure, it is desirable occasionally to remove gasoline from the long leg of the U-tube so as to maintain a slight suction of the bulb at all times.

When the air in the apparatus has become saturated, adjust the levels in the two legs of the U-tube by adding or removing gasoline with the pipet until the levels are equal.

Read and record the cc. increase in volume indicated on the graduated short leg.

Read and record pressure in mm.

Bulb capacity of this apparatus is .....

Substitute in formula below:

$$\text{Vapor pressure (in mm.)} = \frac{\text{Increase in volume (in cc.)} \times \text{Barometric pressure (in mm.)}}{\text{Bulb capacity (in cc.)} + \text{Increase in volume (in cc.)}}$$

Too Much Lime Ties Up Soil Iron. A short time ago, Dr. William Crocker of the Boyce Thompson Institute for Plant Research found a rose-grower of the Middle West who was losing about half of his roses from yellowing of the leaves and stunted growth. The soil had been very carefully limed and tested to make sure that it was neutral or alkaline. It was suggested that the soil was too alkaline, with the side result that the iron was rendered unavailable. The roses, like humans under similar conditions, were anemic, lacking their iron ration. The greenhouse grower did not take very kindly to the suggestion, having gone to great lengths to produce technically perfect, tested alkalinity of the soil.

On his return to the Institute, Dr. Crocker suggested to Dr. P. W. Zimmerman that he try out this point, with the result that in one of the Institute green houses today a jury of roses is deciding the question themselves.

Bushes of one variety grown in rather strongly acid soil are flourishing, while those on slightly alkaline soil are practically on their death-bed. While all roses will not react in the same degree to this condition, still the principle probably holds in general.—*Science Service*

A NOTE ON THE PREPARATION OF HYDRIODIC ACID

T. H. Whitehead, University of Georgia, Athens, Georgia

In the preparation of hydriodic acid from hydrogen sulfide and iodine, it has been found that the formation of iodine on distilling the hydriodic solution can be prevented if the mixture is dialyzed through a collodion membrane for forty-eight hours. This removes the colloidal sulfur which seems to cause oxidation of the hydriodic acid.

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The instructor of inorganic chemistry is so often embarrassed by his inability to explain the results obtained in elementary laboratories that he welcomes help from any source. This note is offered in the hope that it will help clear up one of the many difficulties encountered in the laboratory.

When hydriodic acid is prepared by passing hydrogen sulfide gas into a water solution of iodine, the sulfur formed filtered off, and the filtrate fractionally distilled, there is almost invariably a considerable amount of iodine liberated in the distilling flask and the student wants to know why.

The instructor usually answers that hydrogen iodide is "unstable" and breaks up, when heated, into hydrogen and iodine. This sounds all right and many elementary texts invite this answer even though they do not say outright that hydriodic acid is thermally unstable below 127°C. The author investigated this reaction and thinks the evidence to be presented will show that there is a more valid explanation.

Hydriodic acid was prepared as described above:

$$H_2S + I_2 \rightleftharpoons 2HI + S(?)$$

This equation is the one usually given.

After filtering off the sulfur, the filtrate was transferred to a sac prepared from U. S. P. collodion (nitro-cellulose) and dialyzed against distilled water for forty-eight hours. Care was taken to protect the whole outfit from the atmosphere because hydrogen iodide reacts readily with oxygen to form water and iodine.

The water containing hydrogen iodide which diffused through the membrane was then distilled and no iodine was formed although at times the thermometer went as high as 130°C.

This procedure was repeated three times and uniform results were obtained.

The following explanation is offered. When sulfide ion is oxidized in water solution by iodine, it is probable that more than free sulfur is formed. Odén (*1*) has reported the formation of colloidal sulfur. If a colloidal sulfur complex was formed, it would run through ordinary filter paper but could not dialyze through a collodion membrane. The usual procedure leaves this colloidal sulfur in the solution to be distilled and it reacts with

hydrogen iodide to form iodine and hydrogen sulfide. Dialysis removed the colloidal sulfur and no such reaction took place when the free hydriodic acid solution was distilled.

This offers an empirical explanation which the author thinks is preferable to the loose one of "instability" even though it be more complicated.

Literature Cited

(1) ODÉN, *Z. physik. Chem.*, **80**, 709 (1912).

Malaria Remedies. At the Wellcome Chemical Research Laboratories, London, where remedies for tropical diseases are constantly under investigation, Dr. T. A. Henry and associates are taking advantage of a fact discovered many years ago, that birds as well as men are subject to malaria. So birds are being tried out as experimental animals for proposed new malaria cures, in place of the time-honored guinea pigs, rabbits, and dogs.

Although quinine has been the standard remedy for malaria ever since the Spanish missionaries learned its use from the Peruvians 300 years ago, until within the last few years few efforts have been made to improve upon it or to find other tropical drugs that might be even more efficacious. Now researchers are at work on the problem from both these angles.

One of the promising chemical derivatives of quinine, Dr. Henry states, is an oxidation product, quitenine. It has no effect on malaria, but two of its compounds, the butyl and amyl esters of quitenine, are vigorous in their action against the parasites. However, the most promising derivative yet tested is the reduction product, hydroquinine.

A number of native malaria "cures" from different parts of the world are also under investigation. Alstonia bark has long enjoyed a high reputation in native medicine in Africa, the Pacific islands, and Australia. Akuamma is another African remedy of high repute. Greenheart bark is favored by native doctors in British Guiana. Alkaloids have been isolated from all of these, but only those from Alstonia have shown any activity in bird malaria.—*Science Service*

Missouri Chemists Refine Radium from Watch Paint. Chemists at the University of Missouri, under supervision of Dr. Herman Schlundt, have started in operation the only known factory in the United States for refining radium from the paint off luminous dials of old watches and clocks. Already several thousands of dollars' worth of the precious element has been recovered in this manner.

Out of several hundred pounds of paint about one-hundredth part of an ounce is radium. At the present market price this element is nearly $70 a milligram, or almost $2,000,000 an ounce.

A refining plant for mesothorium, another commonly used radioactive element, was also established by Dr. Schlundt at the University of Missouri and has been in operation several years. Last year between $25,000 and $50,000 worth of mesothorium was refined.

By way of comparison it has been pointed out that mesothorium is worth about $40 a milligram while radium is worth nearly twice that amount. Radium endures thousands of years but its substitute loses one-half its strength in seven.—*Science Service*

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DISPENSING LABORATORY SOLUTIONS

CHARLES F. ECKELS, COMPTON UNION JUNIOR COLLEGE, COMPTON, CALIFORNIA

The efficient distribution of reagents and solutions in school laboratories requires safety, economy, and convenience. Three devices for different kinds of solutions are suggested.

For acid and base reagents a glass siphon with a 4-mm. plug bore glass stopcock at the outlet may be used. The liquid flow is easily and conveniently controlled without waste.

For special solutions a 150-cc. pipet bulb may be used to force the solution out of a 2.5-liter bottle fitted with a glass spout. Only glass to solution contact makes this device useful when purity is to be considered.

For indicators an accurate control of drops is necessary. A buret with a glass bead in the rubber connections to the drawn glass tip makes careful control possible.

. . . . . .

Inefficient methods of distributing reagents and solutions in school laboratories are the cause of much waste of time and materials. Frequently strong solutions are spilled on school property or students' clothing with serious damage to both. Some schools pay an assistant to keep the student reagent bottles filled, but the students are left to help themselves to the special solutions. Safe methods of dispensing all types of solutions would allow the responsibility to be placed on the student with a saving of time and money. Three easily assembled devices, which have been used successfully, are here suggested.

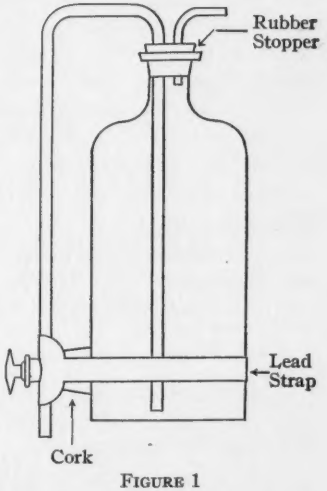

FIGURE 1

Dispensing Acid and Base Reagents

Each student has the use of eight 16-oz. glass-stoppered reagent bottles which are to contain concentrated and dilute H_2SO_4, HNO_3, and HCl and dilute NaOH and NH_4OH. For each of these small bottles a large 2.5-liter bottle (those used to ship small amounts of acids and bases) is placed on a main shelf in a convenient place. The bottle is fitted with a glass siphon, as in Figure 1, made by welding a 4-mm. plug bore glass stopcock to pyrex tubing of the same bore and of sufficient length to make the bends.

If the equipment is at hand to join the tubing with the stopcock the total cost will be a little less than one dollar. The total charge would be about one dollar and a quarter if a glass worker is employed.

The apparatus should be held in rigid position to decrease the possibility of breakage. For this purpose a lead strap may be cut to fit over the tap and about the bottle. (A piece of a large automobile inner tube might be used.) A clasp is fixed in the strap (not shown in figure) for ease in removing the siphon. A cork is bored out to fit the back of the tap and rounded at the other end to fit the bottle. This makes it possible to tighten the strap without interfering with the action of the tap.

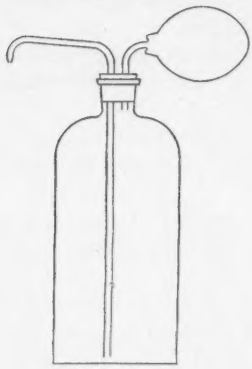

FIGURE 2

One of the holes in the rubber stopper in the bottle is fitted with an air inlet tube. To start the siphon a large-size pipet bulb (as in Figure 2) may be used. Practice will enable one to start the siphon without spilling any of the solution, by closing the tap just before the liquid reaches it. If the solution is to be kept in a very pure condition the air inlet tube may lead through a wash mixture. In the case of basic solutions which should be free from carbonates, a large drying tube containing soda lime may be attached.

The apparatus may be used easily and conveniently by students without danger of spilling acid on clothing. A lead drip tray should be constructed under the eight bottles to protect the floor from occasional drops. Reserve bottles should be kept on hand so that the apparatus may be changed to a new supply without bothersome delay to student and instructor.

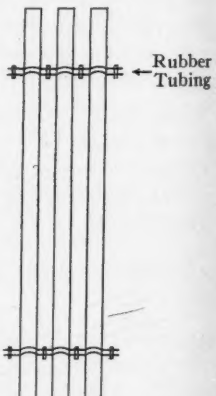

FIGURE 3

Distribution of Special Solutions

The common method of dispensing special solutions involves the tipping of the reagent bottle. Solutions are easily spilled and frequently the amount of solution actually needed is greatly exceeded. In large classes a great amount of solution may be wasted. Much time is needed to tip the bottle and to remove and replace its stopper. To solve these difficulties the apparatus in Figure 2 is suggested. A 2.5-liter bottle is fitted with a No. 5 two-holed rubber stopper. Common small-bore glass tubing is used for the spout and pipet bulb connection. The bulb has a capacity of about 150 cc., which is sufficient volume to force the solution from the bottom of the bottle. The amount

of the solution drawn from the bottle may be easily controlled by regulating the pressure on the pipet bulb. No tipping is necessary, the chance of spilling is reduced and quantities are easily and quickly forced out. Since the bottles do not have to be moved by the students, a special rack may be constructed at the most convenient place in the room. Strongly alkaline solutions would dissolve CO_2 in the air which is drawn back through the solution to refill the bulb. Bulbs may be purchased for about thirty-five cents each.

Distributing Indicators

Laboratory manuals usually call for an exact number of drops of indicators. Unless special droppers are provided, students are apt to use more than is needed and results are obscured and materials are wasted. A few burets attached to the wall by rubber tubing, as in Figure 3, may be used quickly and conveniently to take exact numbers of drops. Instead of using Mohr clamps to regulate the flow, glass beads are used in rubber tubing of proper size. By pinching the rubber tubing at the bead the liquid flows by and is automatically shut off when the hand is removed (a point to be considered with careless students). A large piece of filter paper may be tacked to the floor below the apparatus to absorb any which might be accidentally dropped. The outfit may be easily fastened to a window or door casing as the convenience of position may require.

Sugar Injection Saves Life in Veronal Poisoning. The injection of a large volume of sugar solution into a vein enables the patient or the experimental animal to recover from the effects of veronal poisoning, Drs. A. B. Luckhardt and Carl A. Johnson of the Hull Physiological Laboratory of the University of Chicago have discovered.

Veronal is widely used as a sleeping powder for human patients, as well as in laboratory animals, but its use is not without danger and frequently gives rise to serious poisoning. It was known for some time that veronal is excreted slowly and almost unchanged in the urine. If the excretion of the drug could be hastened, the chances of the recovery of the patient would improve.

Drs. Luckhardt and Johnson succeeded in hastening the excretion of veronal through the kidneys by injection of 5 to 10 per cent grape-sugar solutions into the vein. The injection of about 35 grains of veronal produced a sleep lasting for 40 hours in normal dogs, but if the dogs received from 1 to 2 liters of sugar solution after the dose of veronal the recovery time was reduced to between 14 and 18 hours.

A woman who had taken 60 grains of veronal, apparently with suicidal intentions, was given one and one-half liter sugar solution three to four hours later. The injection produced marked increase in the secretion of urine; in six hours she passed 1100 cc. of urine. Five hours after the sugar injection she could easily be roused and another six hours later showed almost no symptoms from the drug.

There is little doubt that increasing the efficiency of the kidneys by injections of large volumes of fluids will continue to save life in accidental and intentional veronal poisonings.—*Science Service*

MODIFIED VICTOR MEYER APPARATUS FOR THE DETERMINATION OF MOLECULAR WEIGHTS

EUGENE W. BLANK, PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PENNSYLVANIA

A diagram of the Victor Meyer apparatus for molecular-weight determinations is described and results of a typical determination are tabulated. The apparatus is constructed of regular laboratory stock and combines ease of manipulation with a considerable saving of space. Very small quantities of sample are required for a determination.

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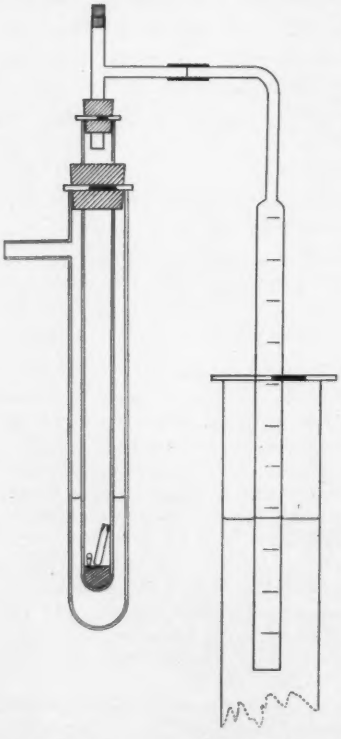
The Victor Meyer method for molecular weight determination is a standard laboratory experiment in physical chemistry, (*1*), (*2*), (*3*). A weighed amount of the substance with unknown molecular weight is vaporized, and the volume which it would have occupied at the temperature of the room and under existing pressure is determined.



The following apparatus was designed to supply the need of a regulation Victor Meyer set-up during the course of experimental work. Constructional details are shown in the accompanying figure. Dimensions are variable, the only requirement being that the inner test tube be of such dimensions that the vaporized sample shall not extend too far up the tube. Otherwise condensation of the sample will take place and vitiate results. The volume of air displaced by the vaporized sample is collected in a graduated pipet immersed in a cylinder of water.

To carry out a determination of vapor density with this apparatus the rubber stopper is removed from the top of the T-tube and the liquid in the outer tube heated to boiling. In ten minutes the temperature will be approximately constant. The cylinder of water is then raised or lowered till the water level is at the zero of the graduated pipet. The stopper is inserted in the T-tube and no change in the water level in the pipet is an indication that the temperature is constant.

A sample of the substance (0.0200 to 0.0250 g.) is weighed into a

small stoppered bulb and dropped on sand or glass wool in the bottom of the vaporization tube. The impact together with the increase in temperature drives the stopper out of the bulb and the substance vaporizes, driving out an equal volume of air which is collected in the pipet. The position of the leveling cylinder is now adjusted and the volume of the displaced air in the pipet is measured. Since the air is measured over water the pressure to which it is subjected is that of the atmosphere diminished by the vapor pressure of water at the temperature of the room.

Calculation of the molecular weight involves correction of the volume of displaced air to 0°C. and 760 mm. pressure and finding the mass of that volume of vapor which will occupy 22.4 liters at 0°C. and 760 mm. pressure. Convenient formulas for the calculation are given by Bigelow (*1*), Walker (*2*), and Getman (*3*).

Typical Determination of the Molecular Weight of Benzene (C_6H_6)

Weight of Sample, G.	*Volume of Vapor, Cm.*^{3}	*Temp., °C.*	*Barometric Pressure Mm. Hg*		*Molecular Weight*	
					Obs.	*Cal.*
0.0228	7.45	20	742.8		77.1	78.05
0.0202	6.68		Corrected		76.2	
0.0148	4.90		725.4		76.1	
				Av.	76.5	

Literature Cited

(*1*) BIGELOW, "Theoretical and Physical Chemistry," The Century Co., New York City, **1912,** p. 165.

(*2*) WALKER, "Introduction to Physical Chemistry," Sixth edition, The Macmillan Co., New York City, **1910,** p. 198.

(*3*) GETMAN, "Outlines of Theoretical Chemistry," Fourth edition, John Wiley and Sons, New York City, **1927,** p. 35.

Ultra-Violet Light for Carbon Monoxide Poisoning. A new method of treating carbon monoxide poisoning with ultra-violet rays brings quicker relief to the patient than ordinary methods of treatment, according to results of a test reported by Dr. Koza of Pressburg. Carbon monoxide produces its poisonous effect by combining with the hemoglobin of the blood, displacing the oxygen which the body's tissues need and which they get from the blood. Some Italian observers had already found that when blood hemoglobin, which was combined with carbon monoxide, was irradiated with ultra-violet light, the carbon monoxide disappeared in from thirty to sixty minutes. Dr. Koza worked on the theory that a considerable part of the blood is in the small blood vessels of the skin. Massage of the skin would stimulate the circulation in these blood vessels and let the ultra-violet rays go deep enough to reach the blood and drive out the carbon monoxide. He tried this method on two sisters who were brought to the hospital because of carbon monoxide poisoning. One sister was treated by the new method, the other by the usual methods for overcoming carbon monoxide poisoning. At the end of forty minutes the first sister had lost half the deadly gas from her blood but the other sister had lost only one-quarter of it. The first sister regained consciousness after nine hours, the second after eighteen hours.—*Science Service*

A DESIGN OF EXPERIMENTAL VACUUM OVEN FOR TEMPERATURES LESS THAN 300 DEGREES CENTIGRADE

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Commercially available electrically heated vacuum ovens which provide for a working temperature above one hundred and fifty degrees centigrade are not sold. In addition, stock equipment is expensive. An electrically heated tube furnace which provides for small-scale vacuum drying at temperatures including three hundred degrees centigrade is herein described. The parts are constructed of standard pipe and fittings, and heat is provided by standard electric space heaters. The details of construction provide for the maintenance of a vacuum of a fraction of a millimeter and the oven has been shown to hold the reduced pressure practically undiminished for periods of twelve hours without pumping. Time-temperature heating curves under different power consumption are given. Modifications in wiring to economize in power consumption are described. This apparatus can be manufactured at a fraction of the investment in stock equipment of more limited range.

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Experimental vacuum ovens from the usual commercial sources are both expensive and limited in working temperature range. For work demanding temperatures between 200 and 300°C. at pressures not greater than a few millimeters of mercury, it is found to be a troublesome problem to provide satisfactory apparatus. For the solution of certain problems dealing with the preparation of various alkaline earth metal perchlorates by dry reactions at temperatures of approximately 250°C., and under pressures of 2–5 mm., the vacuum oven about to be described has proved very satisfactory.

General Characteristics

The vacuum chamber consists of a section of standard six-inch galvanized iron pipe threaded at each end to receive standard pipe caps. The pipe cap on the exit end is brazed to the vacuum chamber and is provided with a $^3/_4$-inch section of pipe threaded and brazed into the center of the exit pipe cap to connect to the vacuum line. The pipe cap used at the open end of the vacuum chamber had its closed side machined away to one-third of its width and served as a collar to support the door to the vacuum chamber. The outside edge of the vacuum chamber at the open end was so machined as to provide an inverted "W" contact surface for the metal door. The top middle portion of the vacuum chamber is drilled and threaded to receive a $^3/_8$-inch galvanized iron pipe nipple to serve as a support for the thermometer used.

The door is made of a disk of iron $^1/_4$ inch thick faced with a disk of lead $^1/_{16}$ inch thick soldered in place. The door was provided with a series of equally placed $^7/_{16}$-inch holes to provide for bolting the door to the collar of

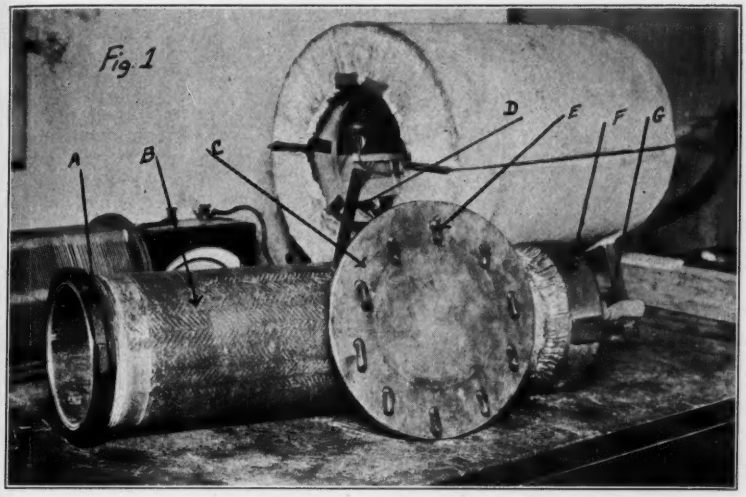

FIGURE 1.—VACUUM CHAMBER TUBE WITH DOOR AND ATTACHMENTS

the vacuum chamber. The bolts used were bent at right angles and threaded at one end to provide for the use of thumb nuts for fasteners.

The vacuum chamber is heated by being placed within a transite board housing with octagonal ends and side pieces to match. Each rectangular side piece of the vacuum chamber housing has mounted inside an electric space heater. The vacuum chamber and transite board housing is placed within a heat-insulating housing made in the form of a cylinder split in half along the vertical axis and dividing the chamber into two equal parts. The transite board housing and sheet metal insulating jacket are supported on a base constructed of strap iron. The sheet metal housing for the heating chamber of transite board provides a two-inch air space between these parts for heat insulation and is coated outside with asbestos paper. Variation in heating value of this system is governed by the use of a low-resistance, high-capacity rheostat connected in series with the heating elements with an A.C. ammeter covering the range 0–15 amperes.

Dimensions and Description of Individual Parts

The vacuum chamber tube with the door and attachments is shown in Figure 1. The dimensions of the individual parts as indicated in Figure 1 are as follows:

A. Standard six-inch black iron pipe cap with all but $^5/_6$ inch of the open end machined off. This collar serves to hold the catch bolts *E* of door *C*.

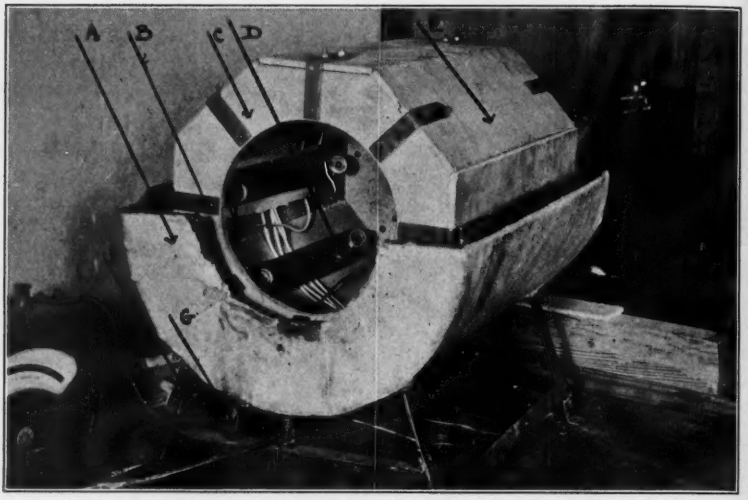

FIGURE 2.—HEATING CHAMBER AND ITS METAL INSULATING JACKET

B. Standard six-inch galvanized pipe $25\frac{1}{2}$ inches long threaded for two inches at each end. The entrance end contact surface is machined to give an inverted "W" shaped contact with the groove $\frac{1}{16}$ inch deep. The vacuum chamber is $6\frac{1}{2}$ inches outside diameter with $\frac{1}{2}$-inch wall thickness.

C. The vacuum chamber door, $10\frac{1}{2}$ inches in diameter by $\frac{1}{4}$ inch thick faced with $\frac{1}{16}$-inch sheet lead. There are ten equally spaced holes $\frac{7}{16}$ inches in diameter placed $1\frac{3}{8}$ inches inside the outer edge of the door.

D. The thermometer tube. A standard $\frac{3}{8}$-inch pipe nipple 5 inches long by $\frac{1}{2}$-inch outside diameter and $\frac{3}{8}$-inch inside diameter.

E. Vacuum door thumb nut clamps. These are made of $3\frac{1}{2}$-inch lengths of $\frac{7}{16}$-inch round iron threaded at one end to receive $\frac{7}{16}$-inch thumb nuts. The $3\frac{1}{2}$-inch bolts were bent at right angles at a point two inches from the threaded end, giving a 1-inch contact to collar *A* for each bolt.

F. A standard six-inch black iron pipe cap used as closure for the exit end of the vacuum chamber. It is brazed to the vacuum chamber and the center of the closed end is drilled and tapped to receive the $\frac{3}{4}$-inch exit tube *G*.

G. The vacuum pump connection consisting of a $3\frac{1}{2}$-inch length of $\frac{3}{4}$-inch pipe nipple threaded and brazed into end plug *F* and tapered at the outside end to receive the rubber tube connection to the vacuum pump.

The details of the heating chamber and its metal insulating jacket are

shown in Figure 2. The dimensions of the individual parts shown in Figure 2 are as follows:

C. The octagonal end piece of the heating chamber. Outside edges $4\frac{1}{2}$ inches in length. The hole is 7 inches in diameter. The transite board is $\frac{1}{4}$ inch thick.

E. The octagonal side pieces of the heating chamber are $\frac{1}{4}$ inch thick, $4\frac{1}{2}$ inches wide, and 15 inches long.

B. Corner brackets, $\frac{5}{8}$ by $\frac{1}{8}$ inch strap iron, each leg 2 inches long fastened with $\frac{1}{8}$-inch by $\frac{1}{2}$-inch round head brass machine screws.

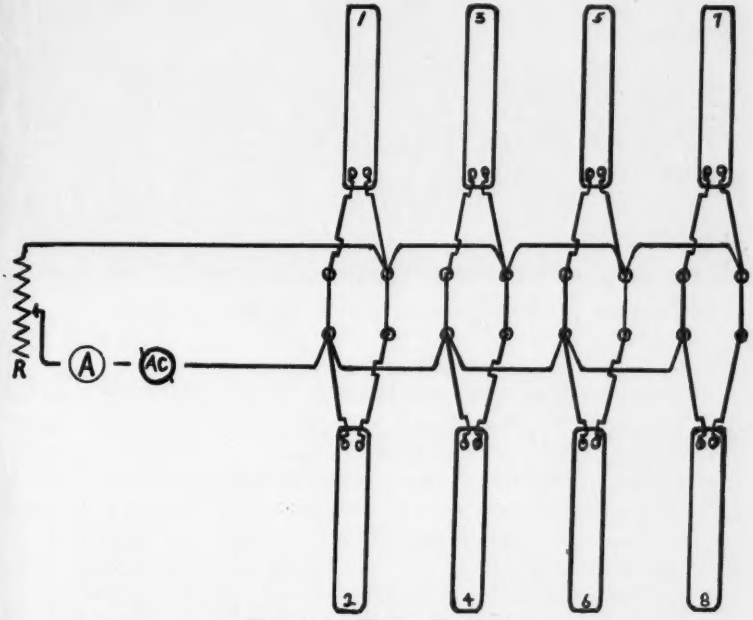

FIGURE 3.—WIRING DETAILS

D. Electrical space heaters, 110 volts, 220 watts, 12 inches long and 2 inches wide (Westinghouse number 299425). Eight space heaters are employed, one for each side of the octagonal heating chamber of Figure 2. The various connecting wires to the space heaters are asbestos insulated. Mounted as shown, no difficulty was observed in keeping the insulation coating unimpaired after several years operation of the heating elements, none of which have had to be changed.

A. The nature of the outer jacket cylinder is obvious from Figure 2. A two-inch air space is provided all around. Twenty-two-gage galvanized iron serves as the metal for the outer jacket.

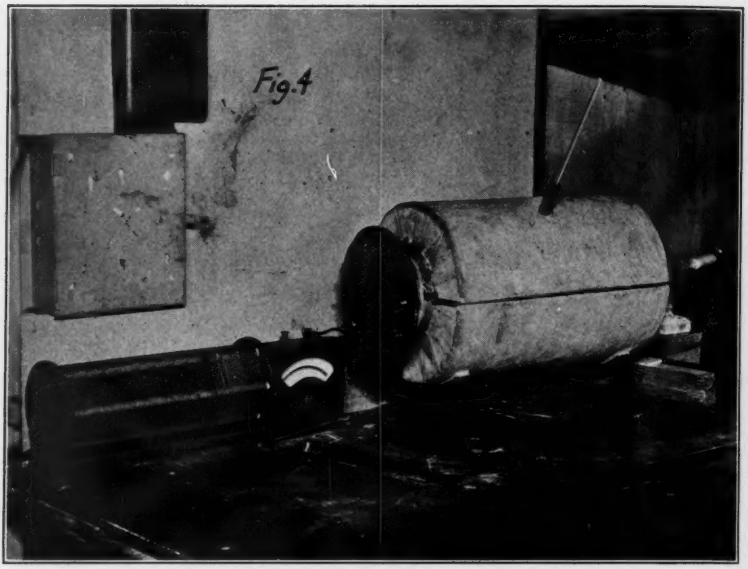

FIGURE 4.—GENERAL ARRANGEMENT OF ASSEMBLED APPARATUS

F and *G*. Line switch and contacts respectively.

The wiring details are shown in Figure 3. The space heaters are connected in parallel and a rheostat *R* and ammeter *A* placed in a portion of the circuit outside the heating chamber as indicated.

The general arrangement of the apparatus assembled is shown in Figure 4. Excessive losses by radiation at each end of the protruding vacuum chamber are prevented by placing a metal shield in the form of a section of a cone from the circular ends back to the metal jacket. These have been removed in Figure 4, giving a more detailed view of the assembled apparatus. It is to be understood in the following description of the performance of this vacuum oven that such heat-insulating caps for each end of the vacuum chamber are employed.

Heat Variation and Control

The heating value of the equipment described is shown graphically in Figure 5. On the horizontal axis is plotted the time in hours during which the vacuum oven is heated and the temperature attained plotted on the vertical axis. Curves *A* and *B* are those for the use of 9 and 11 amperes, respectively. Curve *C* consists of two portions, the almost vertical portion obtained with the use of 12 amperes and the horizontal portion obtained using 11 amperes after the first $2^1/_2$ hours application of the higher am-

perage. By the scheme shown in curve *C* the temperature 250°C. is obtained in three hours corresponding to nine hours using 11 amperes according to curve *B*.

Curve *D* is obtained if the units plotted on the horizontal axis are

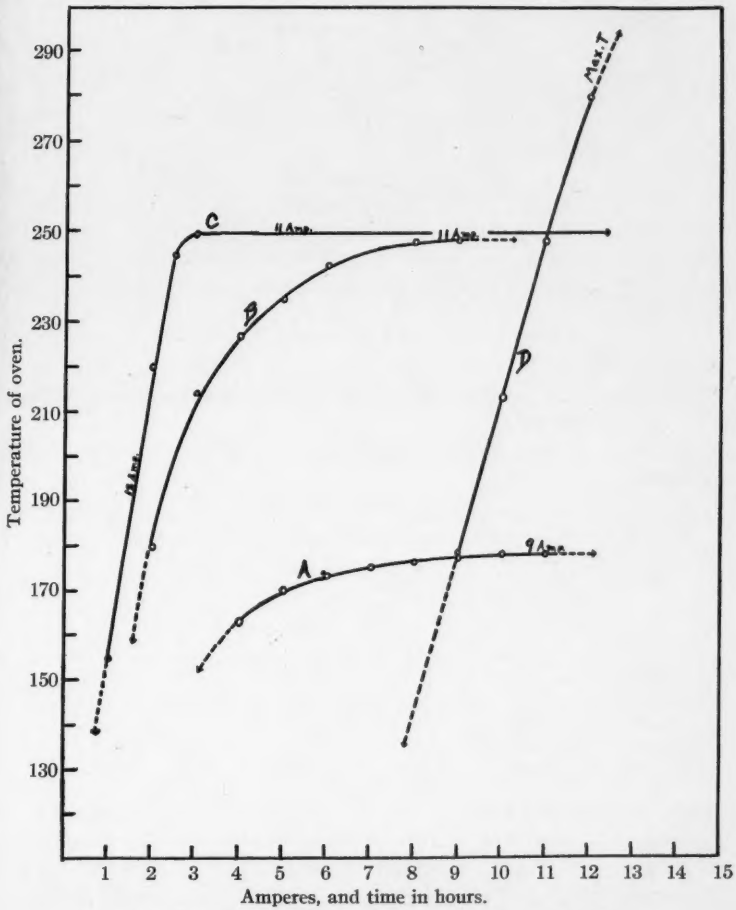

FIGURE 5.—GRAPH SHOWING HEATING VALUE OF THE EQUIPMENT

changed to read amperes instead of time in hours. From an examination of the table the following observations are of note:

Curve *D* being so nearly a straight line, the efficiency of the apparatus described in preventing heat losses is demonstrated. Maximum tempera-

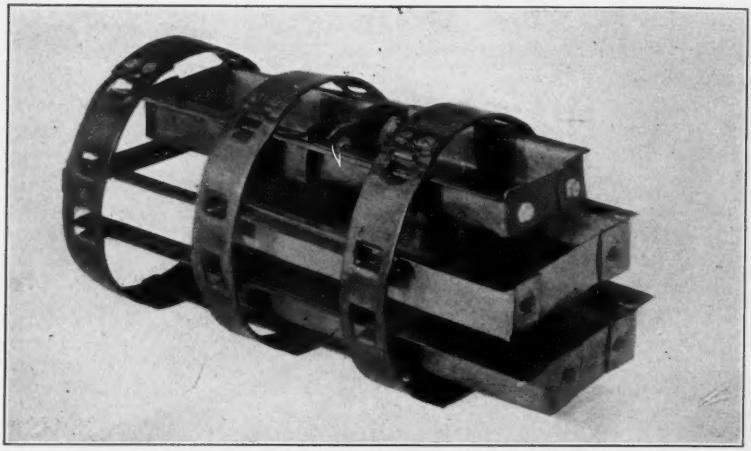

FIGURE 6.—VACUUM OVEN TRAYS AND SUPPORTS

tures of 175, 215, 250, and 285 degrees centigrade are obtained using 9, 10, 11, and 12 amperes.

A summary of the power consumption under varying conditions is given in Table I.

TABLE I

Summary of Vacuum Oven Power Consumption under Varying Conditions

Rheostat resistance = 5.35 ohms total resistance, capacity 15 amperes

Vacuum chamber heating units in parallel = 6.87 ohms

Total Current Used, Amperes	*Total Watts Consumed*	*Rheostat Setting Ohms*	*Power Consumption in Watts*		*Oven Temperature, Degrees C.*
			In Rheostat	*In Oven*	
9	990	5.35	432	558	175
10	1100	3.73	336	746	215
11	1210	2.71	269	941	250
12	1320	1.86	201	1119	285

From an examination of Table I it will be seen that by plotting oven temperatures as abscissa and watts consumed by the oven as ordinates and extrapolation to 150°C., the watts consumed would be 440. At this temperature the wasted energy given off by the rheostat would be equal to that consumed by the oven. At this point it would, therefore, be appropriate to change the space heater wiring. By joining the space heaters by pairs in series, and wiring the four pairs in parallel into the 110-volt circuit, the power realized with the rheostat withdrawn from the circuit would be 440 watts as required to give a temperature of 150°C. For temperatures below this value the rheostat is again employed. Of course, for many

temperatures special wiring of the space heaters would be supplied to avoid wasted energy in the rheostat. The two wirings discussed above have the distinct advantage that they provide a symmetrical distribution of the heat within the oven which is a distinct advantage.

Discussion of General Operating Conditions

By the use of the apparatus described temperatures constant to $\pm 3°C.$ can be easily maintained over long periods of time even with the average fluctuation in line voltage of the commonly employed power line. With sources of power controlled to avoid changes in voltage, temperatures of smaller variation could be easily obtained.

The vacuum realized using a moderate capacity vacuum pump (such as the Mega-Vac) was found to be from 1–3 mm. Shutting off the vacuum pump from the oven at such pressures showed a maximum leakage of 0.5 mm. per hour and oftentimes less. Opening and closing the vacuum chamber repeatedly does not alter the possibility of attaining an equally low vacuum.

The estimated cost of the equipment designed as described is thought to be less than one hundred dollars including material and workmanship.

Cottonseed Meal Used as Fish Feed. Although few fishermen would care to bait their hooks with a string of cotton seeds, it has just been found in the animal nutrition laboratory of Cornell University that cottonseed meal is one of the most satisfactory of the plant products for rearing brook trout.

The meal cannot be fed alone but is mixed in equal parts with dry skim milk and a good fish meal. This dry feed is made into a paste with water and combined with a small amount of raw meat before the fish dietitian casts it to the hungry trout. Among a great many plant foods which have been studied, cottonseed meal excels.

In contrast to cottonseed meal linseed meal is very toxic to brook trout. It will kill them in a few weeks although they are capable of living without any food for several months.—*Science Service*

Chemistry Influenced Whistler's Career. James Abbott McNeill Whistler, the famous painter, told how chemistry influenced his career.

When a young man, Whistler was enrolled at the United States Military Academy at West Point. He was having trouble with his studies in general and chemistry in particular.

In a chemistry examination Whistler was asked: "What is silicon?" He answered, "Silicon is a gas."

West Point record: *James Whistler, discharged June 16, 1854, for deficiency in chemistry.*

Many years later when Whistler had achieved international fame as an artist, he remarked, "If silicon had been a gas, I would have been a major general."

THE RELATIVE HIGH ABILITY OF THE CHEMISTRY GROUP IN COMPARISON WITH THE BIOLOGY AND PHYSICS GROUPS OF THE SECONDARY SCHOOL*

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During a study of overlapping in secondary-school sciences, objective tests pointed out the more thorough scientific preparation of the chemistry group than that of either the biology or physics group. Since the tests and groups were similar, the divergence called for further consideration. The lesser and more unified content of the chemistry course together with the increase of teaching efficiency or pupil interest or both which has resulted from the work of The Chemical Foundation through The American Chemical Society are the two differences discovered that can account for the more thorough scientific knowledge of the high-school chemistry group.

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Introduction

In determining the amount of unnecessary repetition from general science (1) in biology, (2) in physics, and (3) in chemistry, three tests were used. These three pre-tests were made up of (1) items from general science texts repeated in biology texts, (2) items from general science texts repeated in physics texts, and (3) items from general science texts repeated in chemistry texts.

The overlapping items selected were taken from a study of four general science texts and three texts of each of the more advanced sciences: biology, physics, and chemistry. The texts chosen were those in use in the schools participating in the experiment.

Twenty schools in Ohio and West Virginia took part in this study. The schools were selected for two reasons: (1) to obtain a sampling from large, medium, and small high schools; (2) to select to carry out the experiment a personnel with research experience and with which the writer could establish personal contact to assure correct procedures. While several thousand tests were given, in large cities with *X*, *Y*, and *Z* groups, only the test results of a sampling of these groups were used.

TABLE I

The Means and Their Standard Deviations for Groups with Different Instructional Preparation

	Biology Pre-test		*Physics Pre-test*		*Chemistry Pre-test*	
	Group 2 N = 417	Group 3 N = 250	Group 2 N = 374	Group 3 N = 104	Group 2 N = 341	Group 3 N = 104
Means.....	28.58	46.44	31.92	48.74	29.52	64.15
Standard deviation....	20.80	26.35	23.74	27.08	24.85	27.75

* An extract from "Instructional Implications from a Study of Overlapping in Secondary School Sciences," a dissertation presented for the degree of Doctor of Philosophy by R. W. Edmiston, The Ohio State University, August 4, 1930.

The preceding table gives the means and standard deviations of the per cents correct on the items for the groups who have had general science only (Group 2) and the groups who have had both general science and the advanced science (Group 3).

The Relative High Ability of the Chemistry Group

The first abnormal variation shown here is the increase in the mean of the chemistry group over that of the general science group on the chemistry pre-tests. This increase is nearly twice that occurring on the biology and physics pre-tests. It may be due to the nature of the test items or to the nature of the chemistry course.

There are only one hundred twenty-four test items on the chemistry pre-tests. This number of items shows an overlapping of about one-half as much in the case of chemistry as in the cases of biology and physics. The fact that the general science group did no better on the chemistry pre-test does not indicate that these chemistry items were any less difficult and there are no data to give any reason for thinking that the chemical content of the general science course is particularly neglected. Therefore, the chemistry course must be inspected for an explanation.

The outlines formed in making a check of overlapping items show about three-fourths as many items in chemistry texts as in biology or physics texts. There is also an average difference in textbook pages that indicates a chemistry text content equal to about eighty per cent of the biology and physics text content. The possible difference of difficulty in text content presents a further question.

The materials in biology and physics are not as unified as those of the chemistry course. There are the five divisions of physics (mechanics, heat, light, sound, and electricity) to be dealt with and the less distinct these appear as divisions within a physics textbook the greater the number of pages of this book. The variety of new terms* that must be learned by the beginner in biology accounts to some extent for the greater difficulty of this subject.

There may be some further causes for the relatively high standing of the group which has had chemistry. There is no other branch of the secondary-school sciences that has its own organization** and professional magazine† on a national basis. The organization and publication may be

* HESSLER, "First Year of Science," Benjamin H. Sanborn & Co., Boston, Mass., 1925, p. 563. Of the biology, physics, and chemistry terms in this glossary, sixty-five per cent are biology, twenty per cent physics, and fifteen per cent chemistry.

** The Division of Chemical Education of the American Chemical Society.

† The JOURNAL OF CHEMICAL EDUCATION and *The Chemistry Leaflet*, the publications of the Division of Chemical Education of the American Chemical Society aided by The Chemical Foundation.

due to a live body of teachers in the field or the organization and publication may activate the teachers and pupils in chemistry. The pupil and teacher subscribers do not make up one-half of the total subscriptions. This latter fact shows that the JOURNAL OF CHEMICAL EDUCATION furthers an interest in chemistry outside of the school. The American Chemical Society* through the Prize Essay Contest** and the provision of popular books on chemistry, free to school libraries and at a low cost to any interested individual through The Chemical Foundation, has furthered a popularization of chemistry and a recognition of its importance to the world. Such extensive education can hardly fail to affect the teacher and his teaching along with the interest of the pupils in the subject.

The writer knows of no reason why a biology or physics foundation could not accomplish the same thing for biology and physics that The Chemical Foundation has done for chemistry. However, no like problem can be carried out in any field without a generous financial backing. The Chemical Foundation illustrates the need of philanthropy in other educational subjects.

Conclusion

The above considerations lead to the following conclusions: If by lessening the course content by about twenty per cent and increasing the teaching efficiency or pupil interest or both by some national movement such as that fostered by The Chemical Foundation through The American Chemical Society the knowledge added by a secondary-school science course can be doubled, it follows that such moves are needed to benefit the biology and physics or other school courses.

* The Prize Essay Contest is made possible by funds contributed by Mr. and Mrs. Francis P. Garvan of New York City in memory of their daughter, Patricia.

** Prize essays are written upon each of six subjects by three different groups of contestants, high-school pupils, normal-school pupils, and college freshmen. The first prize for the state winners in the high-school contest is twenty dollars in gold. The winning state essays are then judged for the selection of the national winners. There is a prize for each of the six different subjects. These national winners receive a scholarship at any recognized college or university in the United States with tuition paid and a cash allowance of $500.00 per year. The normal school and college freshmen contests are national contests with a first, second, and third prize winner selected in each group upon each of the six subjects. This gives twelve first prize winners, twelve second, and twelve third. The first prizes are $500.00, the second $300.00, and the third $200.00.

Let us learn to dream, gentlemen, then perhaps we shall find the truth. . . .but let us beware of publishing our dreams before they have been put to the proof by the waking understanding.—KEKULÉ

AN ADMINISTRATIVE STUDY ON THE TEACHING OF CHEMISTRY IN THE SECONDARY SCHOOLS OF SOUTH CAROLINA*

G. G. NAUDAIN,** WINTHROP COLLEGE, ROCK HILL, SOUTH CAROLINA

The present study was prepared to determine the status of the teaching of chemistry in the state of South Carolina. The data were secured by a questionnaire sent to the secondary-school teachers of the state and from the State Department of Education. Detailed questions were asked of the secondary-school teachers concerning "The School," "The Class," and "The Teacher." The results of the survey were favorable and placed the teaching of chemistry in the secondary schools of South Carolina practically on a par with other states where similar surveys were made. A review of the results obtained should help the new science teachers in South Carolina to be more readily orientated into their positions. Knowing the existing conditions in the secondary schools, the state of South Carolina can demand higher levels and advance to higher standing.

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Introduction

The purpose of this investigation was to determine how well chemistry was being taught in secondary schools in the State of South Carolina. Similar studies have been made in Iowa (*4*), Oregon (*5*), Ohio (*3*), and Texas (*2*). While some of these other studies included methods of teaching chemistry, the present study determines the relative importance of chemistry in the curriculum, the facilities of the school for teaching it and the qualifications and interests of the teachers. The data were secured by a questionnaire and information from the state superintendent.

A questionnaire† was used in securing the data. Three main divisions were made covering the subjects of "The School," "The Class," and "The Teacher." The questions under the heading "The School" were: the number of students in the school; the number of teachers; the number of students taking chemistry; and the number of teachers in the chemistry department. Under the heading "The Class" the questions were: the number of recitations and laboratories per week and time given to each; the value of the equipment; the space given to chemistry; the attitude of the class toward the subject; and the essays entered in the A. C. S. prize essay contest. The questions under the heading "The Teacher" were: the teacher's training: semester hours credit of the teacher in the

* This survey was made at the request of the South Carolina-Piedmont Section of the American Chemical Society.

** The author wishes to acknowledge his indebtedness to DR. ROE REMINGTON of the Food Research Division of Charleston, South Carolina, for his assistance in securing the data for this study.

† See questionnaire on page 560.

Questionnaire on the Teaching of Chemistry in the Secondary Schools of South Carolina

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The chemistry teacher is urged to give as full and correct replies as possible. The information is being compiled for the purpose of a general survey. Individual replies will not be made public, and will not be preserved after the survey has been completed.

.....High School.....S. C.

A. The School

1. Number of students enrolled in high school.....
2. Number of teachers in high school.....
3. Number of students in junior class.....(Assuming that chemistry is regularly offered in the junior year. If this is not the case, kindly change the word "junior" to read "senior" or "sophomore," as the case may be.)
4. Number taking chemistry this year.....
5. Are there other teachers of chemistry besides yourself?.....If so give names:
.....

B. The Class

1. Number of recitations in chemistry of.....minutes each per week.....
2. Number of laboratory periods in chemistry of.....minutes each per week.....
3. What is the value (approximate), of laboratory equipment in chemistry?.....
Do you have sufficient equipment to perform the required number of forty experiments?.....
4. How much space (approximate), is devoted to laboratory work in chemistry?.....sq. ft.
5. What is the general attitude of the class toward the subject?.....
6. Are any members of your class in chemistry planning to enter essays in the A. C. S. prize essay contest?..... If so, how many?..... Did any write essays for this contest last year?..... Has a state or national prize ever been won by a student from your school?.....

C. The Teacher

1. Of what college or university are you a graduate?.....Year.....
Have you done any graduate work? Specify.....
2. While in college, how many semester or term hours credit did you make in science?..... Divided into Chemistry....., Physics....., Zoology and Botany....., Geology....., others (specify).....
How many semester or term hours in education?.....
3. What is your field of major interest?.....
4. What classes other than chemistry do you teach?.....
5. Are you a member of
   (*a*) The American Chemical Society?.....
   (*b*) The South Carolina Academy of Sciences?.....
   (*c*) The South Carolina Teachers' Association?.....
   (*d*) Any other scientific society, national or state (specify).....

Date.....19.. Signed.....

various sciences; the major field of study by the teacher; other subjects taught if any; and the teacher's membership in various scientific associations.

Supplementary data were secured from the state superintendent of education giving the value of equipments in the chemistry departments and the number of students enrolled in chemistry in the various secondary schools.

Discussion

The questionnaires brought in a great mass of data. Under the heading "The School" the following facts were obtained. The enrolment of the high schools varied from fifty-five to nearly thirteen hundred. The number of the teachers in the high school varied from three to forty-seven. The number in the group taking chemistry varied from seven to eighty-one students. In only a few schools was there more than one instructor teaching chemistry. In many of the smaller schools the teacher taught other subjects besides chemistry.

The State Department (*1*) of Education of South Carolina lists ninety-eight schools in which chemistry is offered. This comprises practically all of the larger four-year public high schools of the state. Among the eighty-six schools replying to the questionnaire, chemistry has a place on the curriculum of seventy-eight or ninety-one per cent. Chemistry was offered in eighty-eight per cent of the eighty-five schools covered by the Texas (*2*) survey. In Ohio (*3*), chemistry was offered in three hundred fifty-four out of ten hundred fifty-six county high schools, and in all of the one hundred eighty-two city and village schools, or an average of forty-three per cent. In Iowa (*4*), although exact figures are not given, the opinion is expressed that of the nine hundred twenty-eight high schools in the state there is little doubt but that chemistry is taught in only about ten per cent of them. Since there are three hundred one four-year high schools in South Carolina, chemistry is taught in at least twenty-five per cent of them.

In regard to the popularity of the course, we find that of nineteen thousand thirty students enrolled in the South Carolina high schools offering the subject, one thousand seven hundred thirty-seven or nine and fifteen-hundredths of one per cent are taking chemistry.

In Iowa, three thousand forty-two of a total enrolment of thirty-four thousand one hundred ninety or eight and nine-tenths of one per cent were taking chemistry.

The answers to the questions under the second main heading "The Class" were equally interesting. It is clearly shown that the secondary schools are very independent and have no common procedures. The number of recitations in chemistry per week varied from three to five. The number of laboratories per week were one or two. The length of the recitations

and laboratory periods varied from forty-five minutes to ninety minutes. The total number of hours in all cases devoted to classroom and laboratory amounted to the minimum set by the State Department of Education.

The value of laboratory equipment was reported by sixty-seven schools totaling forty-eight thousand one hundred fifty-one dollars, or an average value of seven hundred nineteen dollars. Texas (*2*) school authorities recommend a minimum laboratory equipment of three hundred dollars for each class of twenty students. In South Carolina we find: twenty schools, or thirty-one and three-tenths per cent with less than three hundred dollars; twenty-five schools, or twenty-seven and three-tenths per cent with three hundred to five hundred dollars; eight schools, or eleven and nine-tenths per cent with five hundred to one thousand dollars; thirteen schools, or nineteen and four-tenths per cent with more than one thousand dollars.

Eight schools report more than two thousand dollars in chemistry equipment, the highest being four thousand dollars at Sumter. Several reported three thousand dollars. On the other hand we find Cross Hill with eighteen in the class and the equipment valued at seventy-five dollars; Coward with twenty students and one hundred dollars of equipment; Cowpens with thirty-five students and one hundred fifty dollars of equipment; and Hebron with twenty-four students and one hundred dollars of equipment. In spite of the data given above, only six teachers reported having insufficient equipment to perform the required number of experiments. We all know that a real teacher can find ways to do things with poor apparatus, and no doubt pride in their work leads some of our teachers to report adequate equipment, even when reason should tell us that they cannot possibly carry on a suitable course with the material at their disposal.

The space devoted to the laboratory varied from only a few square feet in one room to a couple of thousand of square feet occupying two or more rooms. The space used would follow to a great degree the number of students enrolled and the equipment possessed. The space allowed and other factors involved were generally sufficient to create a satisfied attitude toward chemistry in the classes.

Twenty-four schools reported that students will enter essays in the contest this year with a total number of one hundred ninety-eight students writing. Since this has been made a class exercise in several schools, not all of this number will be represented before the judges of the state of South Carolina. This is a very commendable showing.

The third part of the questionnaire asked information concerning "The Teacher." The majority of the chemistry teachers in South Carolina were from South Carolina colleges. Chemistry was taught by fifty-four men and twenty-five women. All of the seventy-one who reported on their training were college graduates. Thirty or forty-two per cent

had some post-graduate work, although not always in chemistry. Six or nine per cent had the master's degree. Twenty-six or thirty-seven per cent had one year or less of chemistry training, twenty-three per cent had two years, and forty-one per cent had more than two years. Fifty-three reported twelve or more semester hours in education.

The schools attended by the chemistry teachers were as follows: Presbyterian College and Winthrop tied with twelve each; Newberry College had eight; Wofford and the State University each six; the Citadel, four; Furman, Erskine, Clemson and Columbia College, three each; Lander, Piedmont, Charleston, and Randolph-Macon, two each; Mercer, Coker, Limestone, Converse, Due West, Columbia University, Alabama Polytechnic, Duke, Montana, and the University of Florida, one each. Seventy out of seventy-eight were the products of our own state.

The distribution in time of the graduation of the teachers was as follows: 1911 (1), 1916(1), 1917 (2), 1919 (2), 1920 (2), 1921 (1), 1922 (2), 1923 (6), 1924 (8), 1925 (6), 1926 (9), 1927 (6), 1928 (20), 1929 (9). Nearly fifty per cent of the chemistry teachers were not more than three years out of college.

The number of hours of college training in science varied from six to one hundred four; in chemistry, from none to sixty-two; in physics, from none to seventy-four; in zoölogy and botany, from none to twenty-four; in geology, from none to fourteen; and in education, from none to seventy-four.

According to the rules of the State Department of Education it is necessary for a teacher, in order to qualify for a high-school certificate, to complete at least the junior year at college. First-grade academic certificates are issued on degrees from recognized colleges. First-grade professional academic certificates are issued on an A.B. or B.S. degree from an accredited college of this state if accompanied by a transcript showing eighteen semester hours in education.

The Southern Association of Colleges and Secondary Schools requires that seventy-five per cent of the faculty, at least, of an accredited high school shall have the bachelor's degree from an approved college, and that all teachers whose employment began in 1927 or later shall have had not less than twelve semester hours in education. The question arises whether this requirement in education makes it impossible for a college graduate who has followed the chemistry course as laid down to secure a teaching position, or whether these requirements in the field of education are so high as to seriously interfere with the courses in chemistry which should have been taken.

The fields of major interest of the chemistry teachers of South Carolina were: chemistry 27, science 20, biology 8, history 4, home economics 3, mathematics 3, physics 2, psychology 1, literature 1, education 1, Latin 1, and Bible 1.

It was interesting to learn of the teaching combinations in the secondary schools. Undoubtedly, the combinations did not follow the major and minor work in all cases. Necessity called for some unusual combinations, especially in the smaller high schools. There were teachers who taught physics, history, arithmetic, civics, and chemistry, etc. However, in the larger schools the combinations such as physics, chemistry, and general science were used. In the largest high schools chemistry took the entire time of the chemistry teacher.

The chemistry teachers of South Carolina reported that three were members of the American Chemical Society, two were members of the South Carolina Academy of Science, and seventy-three were in the South Carolina Teachers' Association. More of the teachers should be members of the scientific societies in order that they may be professionally alert.

Conclusion

The South in general appears to have a reputation throughout the country of being slow in education. Certainly the results of this survey do not indicate that, so far as the teaching of chemistry in the secondary schools is concerned, this reputation is warranted. The favorable showing of chemistry made in this survey can be considered as applying also to the other sciences. The survey given above will compare favorably with situations existing in other states. However, knowing the existing conditions, the state of South Carolina can demand higher levels and advance to higher standing.

Bibliography

(*1*) South Carolina State Department of Education, 1929 Year Report.
(*2*) Texas State Department of Education, 1929 Year Report.
(*3*) Ohio State Department of Education, 1929 Year Report.
(*4*) Iowa State Department of Education, 1929 Year Report.
(*5*) Oregon State Department of Education, 1929 Year Report.
(*6*) South Carolina Department of Education. Revised Rules and Regulations for the Certification of Teachers.
(*7*) The Southern Association of Colleges and Secondary Schools. Standards for 1929.

Homemade Talkies Aid Chemistry Teaching. Homemade talking movies, made at a cost of $12 as compared with a figure many times as much for the professional article, are being employed at the Medical College of Virginia, Richmond. A 16-mm. home motion picture camera is used to photograph the instructor writing chemical formulas on the blackboard. Then the pictures are subsequently run, and as they are run he talks into a microphone connected with a simple recording apparatus that makes a record on an aluminum disc. When the movies are shown to the students, and at the same time the record is played on a phonograph, an effect of partial synchronization is obtained.—*Science Service*

QUESTIONNAIRE STUDY OF CHEMISTRY FINANCES IN SOUTH DAKOTA

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A wide variety of practices in regard to the collection of chemistry laboratory and breakage fees is revealed from information collected by questionnaires from representative high schools of South Dakota. Schools with limited funds frequently charge a small laboratory fee. A far greater number charge their students for articles they break in the laboratory. In far too many cases the money collected in either case is not expended for the purpose for which it is collected. More care should be exercised in the collection and judicious expenditure of such fees. Chemistry instructors generally should be given more freedom in the selection of laboratory chemicals and equipment.

. . . . . .

A questionnaire study of chemistry laboratory finances (*1*) in the high schools of South Dakota was made with the hope of discovering prevailing practices in regard to the payment and collection of student laboratory and breakage fees in chemistry. Since it is often financial considerations that keep chemistry out of many high schools, it was hoped that by studying present conditions, and possibly suggesting a feasible solution, more schools might be encouraged to introduce chemistry into their curriculums. Jensen (*2*) in the report of his science survey of South Dakota, of 1924–26, gives some interesting data concerning the value of chemistry equipment which teachers have available for the teaching of chemistry in South Dakota. The average value of the equipment for chemistry is $387 based on 46 schools. The median or measure of central tendency for chemistry is $355. That is, 50 per cent of all the cases fall above and 50 per cent below this value. The first quartile for chemistry is $222. This means that 25 per cent of the cases fall below the value given and 75 per cent above. The third quartile for chemistry is $462. That is, 75 per cent of the schools offering chemistry have equipment valued at less than $462 and only 25 per cent of the schools have equipment valued at more than $462. The range shows valuations as low as $50 and as high as $1600. However, he gives no information regarding the collection and utilization of either student laboratory or breakage fees. It is interesting to note that the state laws contain no statute either requiring or prohibiting the payment or collection of such laboratory or breakage fees. The matter is left entirely in the hands of the local chemistry teacher for administration. This study concerns the frequency and advisability of using such sources of income to supplement the regular appropriations from the boards of education to finance high-school chemistry courses.

Questionnaires were mailed to 75 South Dakota high schools. Thirty-six (48%) replied, and of these eleven did not offer chemistry. The results in tabular form follow:

No. of questionnaires mailed.....75
No. of questionnaires returned.....36
No. of schools offering chemistry.....25, representing 4475 students

Of these 25 schools, 23 were regular four-year high schools, and 2 were three-year high schools. The range in enrolment of the 25 schools offering chemistry was 85 to 1300, with an average of 150. The total enrolment in chemistry was 812 (18%) with a class range of 12 to 85, with a mean enrolment of 28 students.

The following statistics resulted from the question: "Do you charge a laboratory fee?"

No laboratory fee charged.....16
Laboratory fee charged..... 9

The nine schools charging a laboratory fee supplied the following information:

Yearly Amount of Laboratory Fee	*Time Paid*	*Duration*	*Use*
$2.00 charged by 4	At beginning 7	Whole year 7	In chemistry department 6
1.50 charged by 1		By semesters 2	Into general fund 3
1.00 charged by 3	At end 2		
0.50 charged by 1			

Concerning breakage fees: Of the 25 schools the requirements were as follows:

Variable individual payment for individual breakage.....5
No breakage fee.....10
Fixed breakage fee in addition to laboratory fee.....10

Those who charged a breakage fee report as follows:

Amount of Breakage Fee	*Time and Duration*	*Use*	*Method of Checking*
$0.50 to $2.50	Beginning of year 5	General fund 5	Ordinary check system 13
Average $1.50	Beginning of semester 3	For new equip-	Honor system 1
	End of year 4	ment in the	Card system 1
	End of semester 3	dept. 10	

In one school the board of education had complete charge and responsibility for the buying of all chemistry equipment; in eight the superintendent had charge of this work; in twelve the chemistry instructor had charge of this purchasing: and in four some combination of the above was used. In twenty instances the board of education appropriated money for chemistry supplies in addition to student fees. In one case it did not. In other cases the custom varied from year to year. These appropriations varied from $25 to $500, and in some cases the amount needed was provided.

Twenty-one instructors who answered were satisfied with their present system of handling fees and supplies. Two were not. Several expressed

the idea that chemistry laboratories are generally too small and crowded. Another disapproved of all chemistry fees, saying that they kept students out of the course.

Instead of showing, as had been hoped, a general uniformity in handling fees and breakage in high-school chemistry, this study shows rather a lack of system. It is plainly evident that this matter constitutes a real problem. Prevailing tendencies seem to favor the collection of breakage, by an advance deposit, for all apparatus needlessly broken by students. An additional laboratory fee is frequently charged, where other sources of income are limited, to provide necessary chemicals and equipment. Such a policy, wisely and honestly administered, should not discourage many students from taking chemistry but rather helps them to appreciate the real value of the training and instruction provided.

Literature Cited

(1) *Cf.* PAYNE and SMILEY, "Chemistry Laboratory Fees," J. CHEM. EDUC., **8**, 133–9 (Jan., 1931).

(2) JENSEN, "High-School Science Survey of South Dakota," *ibid.*, **4**, 897–904 (July, 1927).

Tells of Tests for Dry Cleaning Fluid. Dry cleaning fluid, to work properly, should be clear enough to read ordinary newsprint through $11\frac{1}{2}$ inches of it; should have a sweet odor; should be light in color and free from moisture, fatty acids, and alkali. These are some of a series of 11 tests for the use of dry cleaners to determine when their cleaning fluid is exhausted. At the Cincinnati meeting of the American Chemical Society Ralph A. Morgen and Frank Fair described these tests. In order to give satisfactory results, they stated, it is not necessary that the fluid be maintained at the same specifications as the original, but it should be maintained at a sufficiently high quality to give good cleaning.—*Science Service*

More Solid Carbon Dioxide Now Used than Any Other Form. More solid carbon dioxide, commonly known as "dry ice," is now used than the liquid form of the gas in which it was formerly marketed. D. H. Killefer, chemist of the Dry Ice Equipment Corp., New York City, told members of the American Chemical Society meeting recently at Cincinnati that nearly thirty thousand tons of this former laboratory curiosity will be used during 1930. This is greater than the total amount of liquid carbon dioxide used in 1927, the latest year for which figures are available. It is used for refrigeration, because of its advantages over ice in being colder and in not melting, but changing directly from the solid form into the gas.—*Science Service*

Scientific Riddle Seen in New Weak Solutions. A new riddle for scientists to solve may have been created by recent observations of Prof. Carl Oppenheimer of Berlin and Hermann Junker of Hamburg. These men have been working with extremely weak solutions of metal salts, of hormones, and some of the vitamins. The solutions are so weak that they cannot contain any molecules, as their concentration is one part in ten sextillions. Still these extremely weak solutions, which contain an unimaginably tiny amount of a metal salt or a physiological substance, are able to effect the rate of growth of tiny living organisms, the protozoa.—*Science Service*

Correspondence

AN INTRODUCTION TO THE PRACTICE OF ORGANIC CHEMISTRY

Under the foregoing headline Mr. Garfield Powell, of Columbia University, New York City, has presented a very detailed and exhaustive contribution to the teaching of organic chemistry for universities. In my opinon this paper is the first shot in the peaceful war of liberation of organic chemistry teaching from the fetters of the many evils under which it suffers today. The question whether Mr. Garfield (under the supervision and instigation of Professor J. M. Nelson) has succeeded in showing the right way of procedure is beside the point; the merit of his paper is not touched by it.

If, after a lifetime of teaching organic chemistry, I am allowed to contribute the experience thus gained, and my opinions accruing from it, something may be gained in furthering the endeavor initiated by Mr. Powell. Instead of quoting the several questions raised by Mr. Powell, I take it for granted that his paper has been read with the utmost attention and that thus my references are readily understood. Let us not forget that our discussion refers solely to a course in *practical* organic chemistry, or, in other words, to laboratory work in this branch. It may well be asked whether laboratory work in *any* science or art can enter the scheme of education for general cultural purposes. What are these purposes? In the best sense they are tending to an appreciation of the results of the creative power of the human mind. Hand in hand with this appreciation goes the deeply ingrained tendency, or the desire, of imitation, resulting in the appearance of more or less valuable amateurs. But the really cultured, or shall we term them the *royally* cultured, are warned to despise the handling of *gross* material things. Thus, Philip of Macedon upbraids Alexander for playing a musical instrument so well, asking of him "whether he is not *ashamed* to play so well." And, in the worst of cases these general cultural purposes tend merely to produce *talkers*, who may be very pleasant conversationalists, but, as a rule, disturbers of the peace by misleading an ignorant audience. But, even so, organic chemistry of the laboratory kind may be used (and has been used) as an example of abhorrence by the fraternity of general culture, thus lifting that culture to a still higher plane. Think of it! Now let us ask: does the practice of extraction of caffeine from tea, or from coffee, or from cocoa beans receive the approbation of the culturally inclined? It seems very doubtful. If, instead, the production of ethyl alcohol from wood-fiber was practiced, or, the preparation of morphine from opium; or the obtaining of alizarin from both madder root and anthracene, the culturally minded might be interested, if they can be

interested at all in *any* practical work. Too much has so far been said about culture. If we now attack a much more important point for argument, it is the question whether we should teach starting from the general and then descending to the particular, or inversely. Wöhler, in the preface to his "Examples in Mineral Analysis," has decided in the latter sense. Instead of allowing the student to work his way through all the different determinations, quantitatively, of acids and bases, and then let them attempt for themselves to analyze some mineral, he starts from the analysis of the mineral, and allows the student to find out later on, and by himself, what principles have been followed, once and forever. From this point of view the proposal for the analysis of tea serves admirably, the underlying reasoning being always that it is customarily *easier* for the average mind to go from the special to the general than conversely. Of course, this depends on the previous education, beginning in public school, through high school and college, where the general trend is to start from special cases, *perhaps* with the exception of the study of languages.

Newth, the well-known English chemist, relates in the preface of one of the editions of his "Inorganic Chemistry" that a Yorkshireman or one from Lancashire came to him with his son, so as to teach the boy *how to do copper*. Newth replied courteously that he was prepared to teach him chemistry, but not copper alone. Here we have an example of the so-called *practical* way of education rebuked. How very faulty such practical education really is can be shown by our daily experience with evening and extension classes. A large proportion of students comes from daily routine work, say in physicians' offices, or in health laboratories—to learn the underlying principles of what they are doing, being not at all satisfied with the mere machine drudgery of urinalysis or blood analysis, or similar occupation. On the other hand, we possess books as well as the dictum of physiologists which emphasize the waste of time ordinarily indulged in by the teachers of organic chemistry in telling about a number of things, and allowing the students to perform mostly a number of experiments which are irrelevant to their business. All of these want to do *copper*.

Now between the culturists to the copper men, we stand. We cannot attempt to please every one. I would advise to leave both kinds out of our consideration. Let them obtain their experience in their own way, and regret afterward.

Finally: how did our great masters in chemistry arrive at their results? Almost always starting from the simple (trivial or experimental) individual case and eventually arriving at general rules. And if you look into the history of chemistry, you will find, say, starting from Boyle, that the inductive manner of procedure is, and always has been, the successful one.

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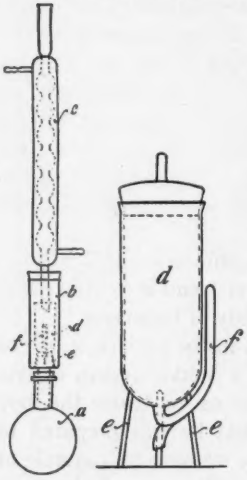
L. H. FRIEDBURG

Abstracts

APPARATUS, LABORATORY PRACTICE, AND DEMONSTRATIONS



Apparatus for the Determination of Residues from Extractions. *Chem.-Ztg.*, **54**, 881 (November 12, 1930).—The extraction apparatus shown in the figure consists of a round-bottomed flask *a*, a connection tube *b*, with the removable extraction vessel *d*, and the condenser *c*. The extraction vessel has the shape of a round-bottomed weighing bottle. It is fitted with a siphon and is supported by three legs made from glass. To determine the residue left after an extraction, place an extraction thimble in the extraction vessel and dry both to constant weight. Weigh 1–2 grams of the substance to be extracted into the vessel and set up the apparatus in the usual manner. It is advisable to keep the thimble two-thirds filled with the solvent during the extraction. Afterward dry the vessel and determine the residue by weighing. The apparatus is manufactured by Richard Schoeps, Duisburg, Albertstr. 24, Germany. L. S.

A Buret for the Determination of Unsaturated and Aromatic Hydrocarbons. J. FORNAMEK. *Chem.-Ztg.*, **54**, 908 (November 22, 1930).—The buret has an inside diameter of 10 mm. There are two bulbs *a* and *b* and a stopcock *k* at its lower end. The upper part is enlarged to a cylinder *c* having a contents of 25 cc. The stopper as well as the neck of the buret contain many small openings *o* which can be closed and opened by turning the stopper. The tube has a volume of 15 cc. and shows divisions of 1/10 cc. The contents of bulb *a* between the stopcock and the zero mark *o* between the two bulbs is 25 cc.; the contents of *b* from that mark to the zero mark of the buret is also 25 cc. Bulb *a* is filled with concentrated sulfuric acid of definite specific gravity (20°C.) by means of a long funnel the tip of which reaches to that mark *o*. The bulb *b* is filled with 25 cc. of benzine to the zero mark by means of a shorter funnel.

The sulfonation is hastened by shaking. The excess internal pressure caused by the heat produced during the reaction can be taken care of by manipulating the stopper. At the end of the sulfonation the buret is allowed to cool to 20°C. The sulfuric acid is drawn off down to the proper mark and the amount of residual benzine is read off on the buret. This buret is patented and manufactured by Alois Kreidl. Prag. I, Husova 7. L. S.

A New Pipet Viscometer. J. ROMNEY. *Chem. & Ind.*, **49**, 986–8 (Nov. 21, 1930).—This new instrument is designed for the rapid determination of the viscosity of lubricating oils. E. R. W.

The Carbazole Reaction for Carbohydrates and Related Compounds. See this title, p. 575.

A Note on the Purification of Mercury. A. O. JONES. *Chem. & Ind.*, **49**, 437T–438T (Nov. 7, 1930).—Descriptions and illustrations of two forms of apparatus designed to purify mercury by aerial oxidation and acid treatment. E. R. W.

The Technic of Extracting Liquids Which Form Emulsions. W. WEINBERGER. *Am. J. Pharm.*, **102**, 594–5 (October, 1930).—Sometimes on extracting material with immiscible solvents (*e. g.*, extracting organic matter out of any aqueous layer with ether) the liquid emulsifies when shaken and does not separate again into two layers. This article tells how to deal with such emulsions. Briefly summarized, they are: (1) Addition of an excess of the dispersed phase. (2) Addition of a solvent common to both phases. (3) Destruction of the emulsifying agent. (If soap, add acid; if albumen, formaldehyde). (4) Salting out. (5) Filtration. (6) Heating, freezing, and electrolyzing. (7) Centrifuging. G. O.

The Detection of Cobalt as Cesium Cobaltinitrites. H. YAGODA AND H. M. PARTRIDGE. *J. Am. Chem. Soc.*, **52**, 4857–8(1930).—The potassium cobaltinitrite used in the conventional scheme of analysis is appreciably soluble and for low concentrations of cobaltous ion precipitates slowly. The corresponding cesium salt is more insoluble, and precipitates and settles more rapidly. Procedure: "The mixture of cobalt and nickel sulfides, from the usual procedure, is dissolved in aqua regia and evaporated just to dryness. The residue is dissolved in one or two cc. of 6*M* acetic acid. To this solution 2 cc. of 6 *M* sodium nitrite and 0.5 cc. of 0.5 *M* cesium nitrate (or 0.25 *M* cesium sulfate) are added and the yellow $Cs_2NaCo(NO_2)_6$ precipitates." H. H. K.

TEACHING OBJECTIVES, METHODS, AND SUGGESTIONS

Film Slides for Modern Visual Demands. W. D. MORGAN. *Educ. Screen*, **9**, 265–9 (Nov. 1930). (*Cf. Photo-Era Mag.*, April, 1930.)—The demand for cheaper and improved methods for projecting still-pictures has now been met by film slides which contain 20–50 pictures on only a few feet of 35-mm. film. Their uses may be three-fold: (1) for public schools and educational institutions; (2) for advertising and selling; and (3) for private use or home entertainment. M. urges individuals to make their own film slides. For his work he uses the Leica camera and projector and the special printing and developing apparatus sold by the Leitz firm. With this apparatus, either the single or double-frame film slides can be prepared with no duplication. For development, the Eastman products are satisfactory. The camera for making film slides is also valuable for making photographs. The cost is so small that hundreds of pictures can be made for about $1. "Pictures are being considered by the educational world as the most positive and economical substitute for real experience." H. T. B.

Chemistry and Education. See this title, p. 577.

An Interpretation of the Dalton Plan. R. B. MARSTON. *High Sch. Teacher*, **6**, 405–6 (Dec., 1930).—In its inception the Dalton plan is said to be "an effort to realize the pupil-centered school." One of its most characterizing features is its provision "for pupil freedom with commensurate responsibility." Some accomplishments which the author claims for the method in his school system are set forth. It improves the pupil's habits of thought. The goal in this matter is "intellectual integrity against dependence upon authority." It trains pupils in the art of schedule construction. This habituates him to the habit of blocking out any enterprise he is entering upon and then "seeing it through."

This plan provides for individual differences. It is obvious that this would be true when it is noted that pupils progress at their natural rate in the work to be done. The author queries, "Is it disrespectful to suggest the possibility that the traditional procedure, depending as it does upon mass movement through subject-matter courses, makes loafers of the most capable pupils?" This plan attempts to care for this weakness "by fixing attention upon the pupil as an individual, establishing him as the focal point in the educational process." That in spite of inferences of some educators to the contrary, "it offers adequate opportunity for socializing experiences." This is accomplished through pupil-teacher, pupil-pupil contacts, through pupil organizations functioning for definite purposes and group conferences. In summary; this method "refuses to teach the plodder he is a failure" and seeks to get "the pupil (to) reach the frontiers of his own capacity and abilities in the direction of his interests." B. C. H.

ADMINISTRATIVE PROBLEMS AND DEVICES; CURRICULA

Some Educational Questions. ROBERT M. HUTCHINS. *Educ. Record*, **11**, 252–60 (Oct., 1930).—President Hutchins raises and partially discusses such questions as: (1) When should professional work be started? (2) What should be the proper length for professional courses? (3) How can the college adjust itself to the individual so that both may profit to the optimum? (4) How can the college keep up desirable standards with an ever-increasing enrolment? (5) How can colleges be organized so that a student who wishes to become a scholar can do so? (6) How in the present system of organization can more individual attention be given to the best students and course examinations, course credits, course grades, and time requirements be minimized?
C. M. P.

Changing and Conflicting Conceptions in Supervision. ORVILLE G. BRIM. *Educ. Method*, **10**, 131–40 (Dec., 1930).—Supervision has passed through several stages of development, each with its own educational point of view, its spirit, its program, and its methods. The supervision has been thought of as: (1) teacher trainer; (2) inspector; (3) helping teacher; (4) scientist; and (5) educational leader. All of these

viewpoints have overlapped to a large extent. The author traces the history of each type and by quoting authorities in the field of supervision points out some of the conflicting conceptions of supervision. In the various current books on supervision the supervisor is depicted as a policeman, as an autocrat, as an authoritative expert, as a teacher helper, or as a dynamic leader in a program of creative teaching. C. M. P.

KEEPING UP WITH CHEMISTRY

Recent Advances in Chemistry. S. C. LIND. *Sigma Xi Quart.*, **18**, 111–7 (Dec., 1930).—The discovery of X-rays in 1895 opened a new era in chemistry. The X-ray is a valuable tool for the study of crystal and atomic structure. The electron provides something tangible on which the chemist may base his conception of the valence bond. The radioactive elements have been added to the periodic family, and greatly strengthened the framework of the periodic table. The Bohr atomic theory did much to untangle the maze in which spectroscopy found itself. Band spectra have been used to disclose isotopes of O_2 and N_2. Catalysis has been much studied and some progress made but chemists are still unable to predict properties of various catalysts except by rough analogy. Chemical kinetics offers two outstanding problems, reaction mechanism and intermediate short-lived reaction products. Colloid chemistry may provide the foundation for the bridge which will enable the chemist to cross into complete understanding of life processes. The geologist has found the rate of accumulation of lead in radioactive ores to be an index of the age of the earth. Astronomers report that 56 of the 90 known elements on earth are present in heavenly bodies. H. T. B.

Some Recent Developments in the Chemistry of the Tubercle Bacillus. JOHN REICHE. *Chem. Bull.*, **17**, 323–5 (Dec., 1930).—The Comm. on Medical Research of the Natl. Tuberculosis Assocn. has under way a program of research on the tubercle bacillus which includes study of the various growth phases of the microörganism, accumulation of data on the chemical composition of the cell and its constituent parts, the effect of the chemical environment, and finally the effect of the isolated chemical fractions of the tubercle bacillus on the tuberculous animal. For such a study as outlined above large quantities of bacteria are needed. A satisfactory growth medium known as Long's medium has been developed which contains K^+, Mg^{++}, $PO_4^{\equiv}$, NaCl, $SO_4^{=}$, asparagin, glycerin, and ammonium citrate. Proteins have been obtained from a few strains of tubercle bacilli and when injected into animals produce reactions of value for diagnosis. Analysis of the organism has shown the presence of several proteins, nucleoproteins, polysaccharides, phosphatides, acetone-soluble fats, and waxes. Evidence indicates that certain polysaccharides play an important part in the immunity mechanism. H. T. B.

The Story of Inks. C. C. PINES. *Am. J. Pharm.*, **102**, 677–88 (Dec., 1930).—Another popular science talk delivered at the Phil. College of Pharm. and Science. Although we have read in our chemistry books that a nation's civilization could be measured by the amount of sulfuric acid it uses, it would seem that it might be more accurately judged by the amount of ink. It has been estimated that there has been three to four million dollars' worth of writing ink used during the past year in the U. S. This story of ink begins with the first ink of the Egyptians used as early as 2500 B.C. and includes a short history of writing fluids, their composition and sources. The word ink is probably derived from a modification of a Latin word, "encaustum," which means "burnt in" because the signatures of the Roman emperors were, figuratively speaking, burnt into the edicts by red ink. The French word for ink is "encre" and the Old English "enke" or "inke." G. O.

What Is a Quantum? PAUL R. HEYL. *Sci. Am.*, **143**, 440–2 (Dec., 1930).—History is prone to repeat itself as well in scientific thought as elsewhere. This has been true of the well-known quantum theory first enunciated by Max Planck. In science as elsewhere old ideas die hard. There were men of scientific standing all through the nineteenth century who clung to the older continuous theory of matter. The last great disbeliever in atoms, Ernst Moch, died in 1916. Energy, like matter, was long thought to be continuous in nature. Now we think of energy as being discontinuous. Light has had a similar history. The quantum theory of Planck (1900) supposed that energy is made up of atoms or quanta. A quantum seems to be indivisible—at least there is no experimental evidence to the contrary. Scientists have no more idea of what a quantum is than we have of the nature of an atom. C. M. P.

The Examination of Cresyl-Bearing Extracts of Ginger. See this title, p. 578.

Benzoyl Peroxide Treatment of Ivy Poisoning. *Am. J. Pharm.*, **102**, 569 (Oct., 1930).—A new method of treating poisoning from poison ivy or poison oak has just been reported to the Am. Med. Assoc. by Dr. Paul Lamson, of Nashville, Tenn., that of

dusting the parts affected with benzoyl peroxide. The therapeutic value lies in the fact that the poison in these plants is toxicodendrol, which can be readily changed into a non-poisonous compound by increasing the amount of oxygen in the compound. Benzoyl peroxide produces this change. G. O.

Seventy Years of Petroleum. F. P. STROUP. *Am. J. Pharm.*, **102**, 631–51 (Nov., 1930).—One of a series of popular science lectures at the Philadelphia Coll. of Pharm. and Science. It relates the history of petroleum, the story of the Drake well, and the petroleum industry today. There are over 400 refineries in our country, handling several million barrels of crude oil daily. G. O.

The Age of the Earth. GEORG VON HEVESY. *Science*, **71**, 509–15 (Nov. 21, 1930).—The non-resident lecturer in chemistry at Cornell gives an explanation of the determination of the age of the earth by various methods. First, by the examination of strata deposition calculations range from 500 to 1200 million years. Second, the sodium content of the sea furnishes a clue and determinations show 360 million years. The decay of uranium and the production of helium provide us with a process going on at a strictly uniform rate. The age of certain rocks has been found to be 570 million years.

This uranium decay produces lead and we need only determine the lead content to find what proportion of uranium has decomposed. This method of computation leads to the belief that Precambrian minerals existed 1260 million years ago and that the earth's crust solidified about 1400 million years ago. The earth, in comparison with the age of certain stars, is rather young. Some of the older stars range from 5 to 10 million years. G. H. W.

Industrial Aspects of Bromine and Its Compounds. G. MALCOLM DYSON. *Chem. Age.*, **23**, 425–6 (Nov. 8, 1930); 450–2 (Nov. 15, 1930).—A review of the sources, manufacturing processes, and industrial uses of bromine and its compounds. E. R. W.

Strychnine Poisoning in Children. JOHN AIKMAN. *J. Am. Med. Assoc.*, **95**, 1661–5 (Nov. 29, 1930).—Although strychnine poisoning is not generally considered as a cause of fatal convulsions in children, A. reports cases and summarizes tabular data concerning accidental deaths due to poisoning of children 5 yr. of age and under to show clearly that it is a frequent cause of death in children and that it is usually caused by accidentally eating medicine prepared for adults. Colored sugar-coated cathartic tablets cause most of the deaths. S. A. L.

Nickel Alloys—Some Personal Experiences. W. R. BARCLAY. *Metal Ind.*, **37**, 414–6; 437–40 (1930).—A historical review of B.'s thirty-five years of personal experiences in the manufacture of Ni alloys. B. tells of his methods of solving the difficulties as they arise, of giving, through inspection trips, his factory employees the user's viewpoint and what the user expects of the metals they use. Emphasizes the factory's scrap heap as the best school for the young student of industrial metallurgy. Advances are made by the manufacturer by the constant study of the use of metals. The importance of research is insufficiently realized. British industry will be led by industrial technologists who have the ability to apply scientific principles of the technical college or university training to the problems they encounter. O. M. SMITH

Hell Broth. GEORGE ALLAN ENGLAND. *Am. Mag.*, **110**, 32–4 (Dec., 1930).—Nitroglycerin, made by "only a simple chemical reaction, that's all," is the "hell broth" of this story. While this compound is made "by the simple action of a mixture of strong nitric and sulfuric acids upon glycerin" the care necessary to keep it from "blowing" requires ingenuity that is of much more than passing interest. Sparks, fires, lightning, and sudden jars are the outlaws in the plant in which "hell broth" is brewed. The visitor finds his personal possessions sorted and all metals, matches, and cigar lighters temporarily confiscated. All of this is in keeping with the lead floors from which you "can't strike a spark." Equally precautionary are the wooden rails for tram cars, soft-soled, sewed shoes for workmen, rubber-covered steps upon all stairs, special containers for all electric wires, and bronze, not iron or steel, tools which do not strike sparks.

Yet the plant described had worked 227 days without an accident and has "lost only seven men in twenty-four years." Between two and three hundred men are employed. Equally interesting to the reader are the striking instances of the difference that high explosives make in doing the world's work. When eight tons of stone can be broken from its moorings with a pound of "powder" at the cost of but two to four cents per ton, it makes a difference. The Monte Salviane tunnel, three and one-half miles long which consumed the labor of 30,000 men for eleven years could now be built by the aid of dynamite by 100 men in less than ten months. And the variety of uses to which this "chemical" seems to be put are almost legion. B. C. H.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES

Second Report of the Committee on Photochemistry, Division of Chemistry and Chemical Technology, National Research Council. HUGH S. TAYLOR. *J. Phys. Chem.*, **34**, 2049–91 (Sept., 1930).—The author limits the report to a discussion of photochemical phenomena in dilute gaseous systems because physical studies of spectra in liquid systems have not yet provided a broad systematization of the absorption act. After Bodenstein and Wagner [*Z. physik. Chem.*, **3B**, 456 (1929)], one Einstein or light-equivalent, E, is defined as the energy of quantized absorption obtained by 1 g. at. or mol. of the absorbing system were each at. or mol. to absorb one quantum of energy of frequency ν. $E = Nh\nu$, where N is Avogadro's const. and h is Planck's const. Analysis of the total photo-process in gases is made under the headings: (*A*) The initial process of quantized absorption. (*B*) The secondary processes of chemical change which succeed the primary process. Under (*A*), absorbing system may be atomic (*a*), or molecular (*b*). Part of the light absorbed by (*a*) is re-emitted as fluorescence but remainder produces photochemical action of types as follows: (1) Energy utilized in exciting other atomic systems electronically ($Hg' + Tl \longrightarrow Tl' + Hg +$ K. E.). (2) Energy utilized in chemical interaction with colliding gases ($Hg' + H_2 \longrightarrow HgH + H$). This is simplest type of *photochemical reaction*. (3) Energy utilized wholly by the colliding gas for a reaction in which the excited atom does not directly participate ($Hg' + H_2 \longrightarrow Hg + 2H$); *photosensitization*. Light absorbed by (*b*) produces more complex phenomena, because of multiple effects which can succeed absorption. Absorption spectra with (*b*) exhibit region of continuous absorption (I), one of discontinuous diffuse structure band absorption (II), one of discontinuous fine structure band absorption (*III*). Within (*I*), atomically bound, homopolar mols. (Cl_2) dissociate optically into one normal and one excited at., while ionically bound, heteropolar mols. (NaI), at longer wave-lengths, yield 2 normal ats. (Na + I) and with decreasing wave-lengths, *i. e.*, with increasing amts. of energy involved, yield (Na + I′), (Na′ + I), (Na″ + I). Within (*III*) apparently an excited mol., (GH)′, is produced. In absence of collisions with other mols. this energy may be re-emitted as fluorescence, but if the excited mol. (GH)′ collides with another gas mol., CD, dissociation into G + H may occur. Within (*II*), also called region of predissociation spectra, phenomena are not clearly understood and problem is still in developmental stage. T. discusses various points of view at some length. Under heading (*B*), T. presents a well-organized discussion of the chemical changes caused by the various types of absorption mentioned above. Numerous examples are considered. The report gives many valuable references to the original literature. S. A. L.

Eighth Report of the Committee on Contact Catalysis. J. C. W. FRAZER. *J. Phys. Chem.*, **34**, 2129–79 (Oct., 1930).—F. gives a general survey of the field. Admission is made at the outset that probably no one mechanism of activation at a surface can cover all cases and the report is full of varying viewpoints. F. quotes Fusinieri [*Giornale di Fisica*, **7**, 259, 138, 371 (1825)] to reveal the modernity of his views. I. *Nature of Catalytic Surfaces.* The picture presented by Taylor is reviewed in some detail. (F. gives complete references.) The idea of Schwab and Pietsch that the "active spots" on catalysts are the edges and corners of crystals is not in conflict with kinetic equations of Langmuir nor with theory of Taylor. Moreover, Smekal points out that imperfections in the crystal, formed during its growth constitute "active spots." Crystals exhibit microscopic cracks over their surfaces and thus present "active spots" at these points. The work of Volmer on supersaturation, of Lennard-Jones and Dent on the field of force outside the (100) plane of a crystal of rock salt, and of Bodenstein on the oxidation of SO_2 on Pt are reviewed. Balandin's "multiplet hypothesis" is discussed somewhat fully. From the work of Rupp on the reflection of electrons from surfaces of metals, with and without the admission of gases, it appears that the crystal lattice of the metal is loosened in presence of certain gases. II. *Adsorption.* Changes in the mols. on adsorption are emphasized. F. mentions 4 theories of adsorption: (1) Langmuir theory. (2) Potential theory of Polanyi. (3) Capillary condensation theory. (4) Di-pole theory. III. *Heat of Adsorption.* This is a complex quantity; includes sometimes, perhaps, heat of reaction when compounds are formed between absorbent and adsorbed material. IV. *The Homopolar Bond and Activation.* Pioneer work of London on relationship between change in sign of resonance energy and activation at a surface is stressed as a promising field for progress. V. *Activation and the Mechanism of Heterogeneous Reactions.* F. discusses work which attempts to discover what causes activation. Hinshelwood and Donnelly suggest that activated mols. may leave surface of adsorbent and initiate a chain reaction in the gas phase. No mechanism discussed is considered as adequate for all cases. VI. *Adsorption from Soln.*

Work in this field indicates that orientation of adsorbed mols. can cause retardation or acceleration of a reaction. VII. *Activation of Charcoal.* Activation of charcoal by H_2O vapor and of sugar charcoal by heating in air are discussed. VIII. *Adsorption of Mixtures.* IX. *Organic Reactions.* The reactions between CO and H_2 which may occur in CH_3OH synthesis are discussed at length, with emphasis on the nature and condition of the catalyst. F. reviews papers dealing with synthesis of higher alcohols, hydrogenation of coal, hydrogenation of unsaturates, catalysts in H_2SO_4 process, decomp. of NH_3, oxidation of CO, decomp. of H_2O_2, the action of antiknocks. S. A. L.

Some Fundamental Definitions of Rheology. EUGENE C. BINGHAM. *J. Rheology*, **1**, 507–16 (Oct., 1930).—About 250 years ago Robert Hooke announced his law of deformation; a few years later Isaac Newton announced the fundamental law of liquid flow. These events may be looked upon as the beginning of the science of Rheology. This science is concerned with the study of viscosity, fluidity, and plasticity of materials. Definitions of the following terms, fundamental in this science, are suggested; consistency, fluid, fluidity, viscosity, viscid, solid, plasticity, yield value, mobility, stiffness, elasticity, rigidity, cohesion, adhesion, strength, length, shortness, hot shortness, cold shortness, toughness, tackiness, hardness, softness, pasty, glutinous, livery, greasy, lean, fat, slippery, lubricant, body, solubility, plasticizer, melting point, workability, thicken, inspissate, temper, cut, brittleness, ductility, malleability. E. R. W.

Plasticity and Viscosity as Criteria of Molecular Aggregation. S. E. SHEPPARD. *J. Rheology*, **1**, 471–83 (Oct., 1930).—A summation and discussion of the attempts of various investigators to relate anomalies in the viscosities of solutions to polymerization or solvation of the solute. E. R. W.

The Carbazole Reaction for Carbohydrates and Related Compounds. J. S. HEPBURN AND M. LAZARCHICK. *Am. J. Pharm.*, **102**, 560–4 (Oct., 1930).—Detailed procedures for performing the tests and tabulations of color reactions for monosaccharides, dissacharides, corn starch, and hydroxy acids are given in this article. G. O.

HISTORICAL AND BIBLIOGRAPHICAL

Walther Nernst. (1) HERZ, *Chem.-Ztg.*, **45**, 1193–4 (Dec. 10, 1921). Brief review of Nernst's work up to the time, 1921, he received the Nobel prize; (2) *Les Prix Nobel en* 1921–22, P. A. NORSTEDT and SÖNER, Stockholm, Sweden, **1923**, pp. 20–1, 22–5, 124: (3) RIESENFELD, *Z. angew. Chem.*, **37**, 437 (1924); (4) BODENSTEIN, *Z. Elektrochem.*, **30**, 301 (1924); (5) SCHMOLKE, *Die Wärme*, **47**, 287–90; (6) LAUE, *Verhandl. deut. physik. Ges.* (3) **6**, 42; (7) ASHER, *Naturwissenschaften*, **10**, 193–8 (Mar. 3, 1922). Stress is laid on the influence of Nernst in the application of physical chemistry to biology; (8) H. v. EULER, *Svensk Kem. Tids.*, **33**, 194–8 (1921). An appreciation and portrait; (9) "Encyclopaedia Britannica," 14th edition, Encyclopaedia Britannica, Inc., New York City, vol. 16, p. 230; (10) "Wer Ist" (German Who's Who) for 1928.

A Newly Discovered Textbook on Alchemy Written around the Year 1300. EDMUND O. VON LIPPMANN. *Chem.-Ztg.*, **54**, 869–71 (November 8, 1930).—Volume VII of the large "Catalogue des Manuscrits Alchimiques Grecs" edited by the eminent Italian historian C. O. Zuretti is a book discovered by him recently in the library of the Vatican. This book written by an unknown author around the year 1300 deals with the "Metallic Art or the Transformation of Metals into Gold and Silver." The book is 466 pages long and it describes thoroughly the chemical knowledge of those days. It was written in Southern Italy in the Greek language. The author deals with metals and the chemicals necessary for their transformation. His ideas are based on the teachings of Hermes that all materials, hence also metals, consist of sulfur and mercury. The common metals contain impurities; they are diseased, leprous, but they can be cured by means of the metallic art. Fire and the "four spirits" are necessary for this cure. Most alchemists meant sulfur, mercury, arsenic, and salmiac by the term "four spirits." However, they did not all agree. Some classified mercury under the bodies (base metals) and the salmiac under the salts and considered some products of the animal body as spirits, namely blood, urine, hair, eggs, etc. The action of these spirits was active, masculine, that of the bodies passive and feminine. Mercury was considered to be feminine, iron and tin were masculine; iron because of its strength and tin because of the noisy tin cry.

Mercury is also called Hermes because it belongs to the planet Hermes (Mercury). It is a living liquid but can be killed (finely distributed) by grinding it with fats. It reacts with tin to form cinnabar from which it can be obtained by the use of an altinkar (Arabian), a mixture of salmia, saltpeter, and alkali. Mercury is volatile without decomposition, on heating it forms poisonous vapors. It forms Sulmáton (Sublimate) when treated with vitriol or alaun and salt. The book describes a number of other

metals (copper, iron), salts (kali, al-natron, salmiac = Halás ammoniakóu, saltpeter = Halas petrae, alouns, vitriols), and acids (Hýdor akoútium = aqua fortis). L. S.

The Death of Professor Eijkman. EDIT. *J. Am. Med. Assoc.*, **95**, 1673 (Nov. 29, 1930).—Dr. Christian Eijkman died at age of 72. He was prof. of hygiene in Univ. of Utrecht, a Nobel prize winner, and the scientist who first produced experimentally a disease of dietary origin. From his observations of polyneuritis in birds, fed on a diet of polished rice, the present knowledge of vitamins has developed. S. A. L.

Dr. John William Nowell. C. S. BLACK. *Ray*, **7**, 10–1 (Dec., 1930).—Obituary with portrait. O. R.

The Seventieth Birthday of Wilhelm Eschweiler on December 1, 1930. WILHELM BILTZ AND KARL SEUZERT. *Z. angew. Chem.*, **43**, 1037 (November 29, 1930). L. S.

Franz Wald. J. BABOROVSKY. *Chem.-Ztg.*, **54**, 905–6 (November 22, 1930).—Obituary. L. S.

Karl Daniel. W. BOTTGER. *Chem.-Ztg.*, **54**, 869 (November 8, 1930).—Obituary. L. S.

Jean Leonard Marie Poiseuille. MARCEL BRILLOUIN. *J. Rheology*, **1**, 345–8 (July, 1930).—This article was translated from the French by Edith S. Bingham. Poiseuille was born in Paris in 1797, he appears to have spent his life there, he died in 1869. Not much is known of his early training but Alexis Petit, his teacher in physics, appears to have had strong influence on him in his later work. Poiseuille served as unattached (*libre*) professor of medical physics, he was never official professor of the Faculty of Medicine. His first researches had to do with the action of the heart and with the circulation of the blood through the system. These were carried out from the physical as well as the physiological viewpoint, and led directly to his study of the flow of water through tubes, and to his important generalization on viscosity. E. R. W.

Seventy Years of Petroleum. See this title, p. 573.

The Nightshade Gatherers—Rhizotomi. F. B. KILMER. *Am. J. Pharm.*, **102**, 698–701 (Dec., 1930).—"Rhizotomi," a name given to a group of men who devoted themselves to the calling of gathering and preparing roots and herbs to be used in medicine. The stories that come down to us about these men show us that while they mixed magic with their medicine, they were not all superstitious fakirs. They did carry on their labors under a ritual of prayer, but some of these herb gatherers of antiquity were men who investigated drug plants in a rational and scientific manner; and scrupulous care was taken to protect them against "corruption" by fermentation and mold. They demonstrated that the human system became immune or habituated to the effects of drugs, using their own stomachs as test tubes and then devising antidotes for poisonous drugs. Even in our time we have the "peripatetic medicine man" or nightshade peddler, for even laws that regulate the sale of poisonous drugs have not stopped the traffic in such things. Among the ranks of the old herb doctors, however, have come physicians and botanists, men of character and learning who helped to lay the foundation of medicine, surgery, dentistry, materia medica, chemistry, and pharmacy. G. O.

Boric Acid in the Glaze of the Sealed Vases of Arezzo. R. NASINI. *Nature*, **126**, 877–8 (Dec. 6, 1930).—The vases of the famous Arezzo pottery are among the most beautiful and important of the artistic works of the Romans of the first century before and after Christ. The author has examined the glaze upon fragments of this pottery and is able to affirm with certainty that boric acid is a constituent part of the glaze and not incidental. This is of interest since it is the earliest definite use of boric acid and doubtless bears a relation to the boric acid "soffioni" of Tuscany. F. B. D.

EDUCATIONAL MEASUREMENTS AND DATA

How Successful College Students Study. JAMES D. WEINLAND. *Educ. J. Psychology*, **21**, 521–6 (Oct., 1930).—This is the resumé of an intensive study carried out with twenty-five commerce students in New York University. Twenty of these were honor students. A questionnaire consisting of seventy items was first used, followed later by a personal interview. The major conclusions from this study were: (1) all the good students were able to work alone and most of them did study alone; (2) the avoidance of distractions, particularly noise stimuli, is important; (3) successful students make it a practice not to work when tired; (4) most of the good students worked by assignment; (5) good students keep fairly full notes, cramming is considered valuable when necessary; (6) successful students have enough interest or purpose in their work to recall and think over what they have heard and read; (7) ability to read rapidly; (8) most of the good students were social; (9) good students usually have hobbies. C. M. P.

PHILOSOPHY OF EDUCATION

Chemistry and Education. WILLIAM MCPHERSON. *Science*, **71**, 485–93 (Nov. 14, 1930).—This is the address of the president of the American Chemical Society, Cincinnati, September 10, 1930. Two methods of treatment of chemistry are open to us: (1) we may separate our students into two classes, according to whether or not they intend to make chemistry their life work, and give to each class courses differing fundamentally in character; or (2) we may so shape our introductory course that it will serve the aims of education and be of value to all students alike. There are objections to both methods. The author is of the belief that the latter course is the more important.

What then should be the character of our introductory course in chemistry, to the end that it will be in harmony with modern views concerning education, and with the function of the contribution to be made by scientific training? (1) In the first place the subject must be chemistry; not merely a collection of interesting facts illustrated by striking experiments in which the fireworks entirely blind the students to the principles involved; (2) the central aim should be the development of the scientific habit of thought; (3) the end of trained thinking is scientific control; (4) we should not lose the opportunity afforded to teach regard for natural law; (5) another fundamental fact to stress is the oneness of all science; (6) many of the topics that lie within the domain of chemistry are not only of fundamental importance to an understanding of the science itself but illustrate in an admirable way the development of the scientific method of study or some other important principle; (7) if history is of value in bringing to us the experience of the past in order that it may be a guide to us in the present, then it would seem that the history of our science may well play an important part in our general course.

And finally the teacher of chemistry, in his enthusiasm for the value of science, must not forget that after all science is not everything. G. H. W.

What Should College Students Learn? GOODWIN WATSON. *Progr. Educ.*, **7**, 319–25 (Nov., 1930).—Some progressive elementary schools have incorporated sweeping changes in their philosophies and programs and have attuned them to the demands and needs of modern life. A few secondary schools have fallen in line, but all colleges have remained immune. The author enunciates the following seven principles of learning upon which a truly progressive school might be established: (1) the principle of activity; (2) the principle of specific learning; (3) the principle of forgetting; (4) the principle of the ability of adults to learn; (5) the principle of readiness; (6) the principle of individual differences; and (7) the principle that life is too short to waste much of it upon the useless and unpleasant. His progressive college based on these principles would include, among other major departments, the following: (1) department of health (mental and physical); (2) department of home participation; (3) department of purchasing; and (4) department of leisure. C. M. P.

What Do We Mean by Progressive Education? WILLIAM HEARD KILPATRICK. *Progr. Educ.*, **7**, 381–6 (Dec., 1930).—Progressive education is based on the new idea that education must be based on careful study. Progressive education intends to base itself on the conscious study of education as opposed to mere tradition. It aims to make an "all-round careful study" of education. It concerns itself with the whole child rather than little pieces of knowledge, separate skills, separate habits, and the like. The second plank of progressive education is that all learning is an active affair and that it involves the whole child. *Behaving* and *learning* are two sides of one process. What is done we call *behaving*. The effect left in the person we call *learning*. Learning is an adjusting, good or bad. The traditional school centered its attention on a few things and ignored the rest. Progressive education founds itself on the total learning effects, stressing both life and experience and giving the whole child an all-round experience. C. M. P.

Changing and Conflicting Conceptions in Supervision. See this title, p. 571.

An Interpretation of the Dalton Plan. See this title, p. 571.

PROFESSIONAL

The Census and the Teaching Profession. RALPH DORNFELD OWEN. *Phi Delta Kappan*, **13**, 97–103 (Dec., 1930).—The desire of barbers to be classed under the census classification as a profession and the establishment of a "Professorship of Plumbing" in one of the technical schools prompts the question, "What is a profession?"

The author lists five characteristics: (1) ideal of service to humanity rather than for profit; (2) specialized knowledge and skill preserved in technical language; (3) protracted period of preparation; (4) life membership; (5) effective organization.

An examination of the status of teaching as a vocation results in some doubt as to its placement. It perhaps fails most noticeably in the characteristics numbered two, three, and four as listed above. B. C. H.

CONTEMPORARY NEWS AND COMMENTS IN CHEMISTRY AND EDUCATION

Uncle Sam Becomes Vocational Counselor. MAJORIE VAN DE WATER. *Sci. News Letter*, **18**, 342 (Nov. 29, 1930).—The U. S. Civil-Service Commission is preparing a series of vocational tests which will be given to high-school students and will give some indication as to the vocation any one student should enter. These examinations are designed to test not so much what the applicant has learned by rote, but more his native ability and his aptitude. H. T. B.

The De-Nationalization of Helium. HENRY B. MILNER. *Nature*, **126**, 920–1 (Dec. 13, 1930).—This is an account of the helium situation in the United States. It quotes a Department of Commerce Press release showing that the helium output for the fiscal year ending June 30, 1930, attained the high figure of 9,800,000 cubic feet. The communication contains the statement, "Under present conditions it costs less to operate government airships with the non-inflammable helium than it would cost to operate them with inflammable hydrogen."

In view of disasters like that of the R-101, an international call for exported helium could not remain for long unheeded in the interests both of humanity and the future of the airship. It is evident that the Department of Commerce will sanction the exportation of reasonable amounts of helium when both its purpose and destination are set forth. F. B. D.

The Examination of Cresyl-Bearing Extracts of Ginger. PETER VALAER. *Am. J. Pharm.*, **102**, 571–4 (Oct., 1930).—From March to July it was estimated that approximately 20,000 people had felt the effects of poison-bearing ginger. Hundreds of samples were sent to the Bureau of Industrial Alcohol for analysis. Examination showed the presence of a cresol compound which was soon identified as tri-ortho-cresyl phosphate. Investigation disclosed that reference books did not list this ester as a poison or one that would cause paralysis. It was the work of the Hygienic Laboratory working under the direction of Dr. Maurice Smith that brought to light its physiological properties, thus opening up a new field of pharmacology. The subjects used by Dr. Smith were calves, and the idea was suggested to him through a midwestern veterinarian who paralyzed his ailing calves by dosing them with fluidextract thinking that he was giving them an old-fashioned remedy. Dr. Watkins of Tulane University working independently found that chickens could be readily paralyzed with the adulterated ginger. Many theories were advanced as to the cause of the paralysis outbreak. Among these was the possible presence of poisonous roots foreign to ginger; but this was considered as quite out of the question since ginger is a large and definite agricultural pursuit. It was probably the work of an ingenious underworld chemist. The purpose of adding this adulterated ingredient was solely to substitute a tasteless, inert solid for the true oleo resin of ginger so that the product would be less pungent and fit for beverage use. He probably did not reckon on its poisonous properties. Tri-ortho-cresyl phosphate is one of the most stable esters in organic chemistry. It is sold in large quantities under various trade names as a liquid plasticizer and is used extensively in lacquers, leather dopes, airplane finishes, etc. There is no record of any kind of any paralysis cases occurring from ginger root, ground ginger, ginger ale extract, or ginger ale. —G. O.

Preliminary Program, Indianapolis Meeting, A. C. S., March 30th–April 3rd. See page 580.

Some International Problems of Chemists. GUSTAVUS J. ESSELEN. See page 582.

McGregory Hall of Chemistry at Colgate University. R. C. ROBERTS. See page 586.

Dedication of Mackay Science Hall, University of Nevada. See page 592.

Purdue Research Foundation. See page 593.

More Powerful Radiations Foreseen as 30,000,000 Volts Are Predicted. See page 594.

Nobel Prize to Dr. Landsteiner for Blood Group Discovery. See page 595.

Science Attacks Problems of Drug Addiction. See page 595.

Chemical Map of North America. See page 596.

Outstanding Educators Will Pick Best Articles on Education. See page 596.

Organizations Act on Educational Situation in Mississippi. See page 597.

Proposed Change in System at Phillips Exeter Academy. See page 597.

American Association of Teachers of Physics. See page 598.

American Contribution to Royal Institution. See page 598.
Jubilee of Society of Chemical Industry. See page 599.
President of American Institute of Chemists Honored. See page 599.
Dr. LaMer to Visit Stanford University. See page 600.
Summer Courses in Chemical Microscopy at Cornell University. See page 600.
Sigma Xi Chapter at the University of Pittsburgh. See page 600.
Meeting of New York Alumni of Worcester Polytechnic Institute. See page 600.
Death of Richard B. Moore, Isolator of Radium from American Ores. See page 601.
Dr. Williams Joins Staff of Battelle Memorial Institute. See page 602.
Department Changes at Georgetown College. See page 602.
Fraternity Award to Student at University of Akron. See page 602.

GENERAL

Science and Modern Industry. WM. J. POPE. *Chem. & Ind.*, **49**, 966–70 (Nov. 14, 1930).—"Many thousands of years since, at a time prehistorically distant, man existed on this planet as a creature practically indistinguishable, physically and mentally, from his descendants of today." The languages of ancient man were probably more expressive and flexible than any modern tongue, and the delicacy and perfection of the great literature of the past has never been surpassed in recent times. The work of the goldsmith and the sculptor of five thousand years ago defies modern competition. "It may, indeed, be asserted that in many of the arts, in literature, and perhaps also in such abstract subjects as moral philosophy, no progress has been made for many centuries past; no novel conception has been introduced, and the only change consists in the representation of the age-old material in a form which meets the taste of the current period." These branches of knowledge have long been developed practically to the limits of what is intellectually possible, a great advance can take place only with the exercise of some previously unsuspected faculty of human intelligence. "That faculty finds expression in the study of the natural sciences."

Natural science is concerned with the collection and correlation of precise observations of fact; modern industry deals with the application of exact knowledge to production. E. R. W.

Girls Equal Boys in Mechanical Ability. The ability of children to succeed in vocational and trade school courses is independent of their ability in the more scholastic subjects. Children lacking in intelligence may be superior in mechanical ability. And, despite tradition, girls equal boys in this aptitude. These are among the interesting facts indicated by tests recently devised at the University of Minnesota under the direction of Professors Donald G. Paterson and Richard M. Elliott. The tests were used to measure mechanical ability in a group of junior high-school pupils. It has been proposed that the tests be used to aid immigrants coming to the United States to find the work for which they are best fitted.—*Science Service*

New Fumigant for Grain Eliminates Fire Hazard. Development of a new method of fumigating grain in storage without incurring a fire hazard is an outstanding achievement of government scientists during the past year, Dr. C. L. Marlatt, chief of the Bureau of Entomology of the Department of Agriculture, reveals in his annual report.

The new fumigant is a mixture of solid carbon dioxide or "dry ice" and ethylene oxide. Tests by commercial handlers of grains have proved the value of the method, which, due to its non-inflammability, is economical and superior to the more familiar carbon disulfide treatment of grain.—*Science Service*

Cosmic Rays Explain Reported Superradiation. Reports from Vienna crediting Prof. V. F. Hess of the University of Graz with discovery of highly penetrating radiation ten times more powerful than the strongest radium rays are believed to refer to the cosmic rays which have been studied by Dr. R. A. Millikan, American physicist, and other scientists here and abroad for several years. Cosmic radiation has intensities about ten times that of radium rays. It is probable that Prof. Hess was describing research upon these rays.—*Science Service*

Contemporary News in Chemistry and Education

PRELIMINARY PROGRAM, INDIANAPOLIS MEETING OF THE A. C. S.

MARCH 30–APRIL 3, 1931

The January 20th *News Edition* of *Industrial and Engineering Chemistry* contains an outline of the general plans for the 81st meeting of the American Chemical Society. The preliminary announcement of the program of the Division of Chemical Education was published in the January issue of the JOURNAL OF CHEMICAL EDUCATION [8, 180 (Jan., 1931)], while final details will appear in the April, 1931, issue which will come from the press about March 20th. The complete program for the entire meeting will be published in the March 20th *News Edition* of *Industrial and Engineering Chemistry*.

The following Divisions will devote one or more sessions each to the presentation and discussion of papers: Agricultural and Food Chemistry, Biological Chemistry, Cellulose Chemistry, Chemical Education, Colloid Chemistry, Gas and Fuel Chemistry, History of Chemistry, Industrial and Engineering Chemistry, Medicinal Chemistry, Organic Chemistry, Paint and Varnish Chemistry, Petroleum Chemistry, Physical and Inorganic Chemistry, Rubber Chemistry, Sugar Chemistry, and Water, Sewage, and Sanitation Chemistry. These meetings will be held in the Claypool, Lincoln, and Severin Hotels, which are within very convenient distances of one another.

Program of the Division of Chemical Education. While it is too early to forecast the details at this writing (February 1st), the Divisional program will be integrated with that of the general society essentially as follows:

Monday, March 30

8:00 A.M. Breakfast meeting of the Executive Committee of the Division of Chemical Education. (Claypool Hotel)
2:00 P.M. Meeting of the Council of the A. C. S. (Lincoln Hotel)
7:00 P.M. Subscription Dinner and Dance. (Claypool Hotel)

Tuesday, March 31

9:30 A.M. Symposium on "Coöperation between Industry and Chemical Education." Under the auspices of the Division of Chemical Education. DR. FRANK B. WADE will preside. (Claypool Hotel)
12:00 M. Division luncheon. (Ball Room, Columbia Club). Complimentary to teachers of high-school chemistry.
2:00 P.M. Division of Chemical Education. Miscellaneous papers.
5:00 P.M. Meeting of editors, JOURNAL OF CHEMICAL EDUCATION and *The Chemistry Leaflet*.
6:00 P.M. Editors' dinner.
7:30 P.M. Complimentary smoker and entertainment. (Ball Room, Indiana Theater)

Wednesday, April 1

7:30 A.M. Breakfast meeting, group of Divisional officers. (Louis XIV Room, Claypool Hotel)
9:00 A.M. Meeting of the Senate of Chemical Education. (Claypool Hotel)
11:00 A.M. Meetings of standing committees, Division of Chemical Education. (Claypool Hotel)

2:00 P.M. Division of Chemical Education. Miscellaneous papers. (Claypool Hotel)
5:00 P.M. Business meeting, Division of Chemical Education.
6:00 P.M. Group dinners.
8:30 P.M. Public address, WM. C. ROSE, "Dietary Facts and Fads." (Keith's Theater)

Thursday, April 2

8:00 A.M. Busses leave Claypool Hotel for an all-day trip to Bloomington to dedicate the new chemistry building at Indiana University. [See J. CHEM. EDUC., **8**, 392–4 (Feb., 1931).] The excursion is sponsored by the Division of Chemical Education. Members who elect to take the trip will be the guests for the day of Indiana University and the Limestone Associations. Reservations must be made in advance. Busses will return to Indianapolis before 6 P.M.

Friday, April 3

8:30 A.M. Optional inspection trips to Eli Lilly & Co., Van Camp Packing Co., Republic Creosoting Co., Reilly Chemical Company, Reilly Laboratories, U. S. Encaustic Tile Works, Marietta Mfg. Co., and the Prestolite Co.

Registration. The Registration Bureau will open at 9 A.M., Monday, in the Claypool Hotel and will continue there at 8 A.M. on Tuesday and Wednesday.

The Convention registration fee, required by vote of the Council to help carry local expenses, has been fixed at $3.00 for members and guests other than American non-member chemists; $8.00 for American non-member chemists.

Hotel Reservations. Reservations should be made with the hotels direct. In case of difficulty address the chairman of the housing committee, WM. HIGBURG, 1605 Merchants Bank Building, Indianapolis.

Papers. By vote of the Council of the A. C. S., papers by American chemists not members of the A. C. S. shall not appear on the program unless they be joint papers with society members, and no papers may be presented at a meeting unless the title has been printed on the final program. Papers for the symposium on "Coöperation between Industry and Chemical Education" will be by invitation.

Titles for papers designed to be read before the Division of Chemical Education should be sent as early as possible to the Secretary of the Division, while the *completed* paper together with two copies of an abstract must be received not later than March 1st. Manuscripts which reach the Secretary after this date will be held over, with the author's consent, for a subsequent meeting.

Papers read before the Division become the property of the Society, and, if acceptable for publication, will appear later in the JOURNAL OF CHEMICAL EDUCATION.

Since the time available for each paper will be strictly limited, authors are earnestly requested to coöperate as follows:

1. Condense the material so that it may be presented in 5–8 minutes, leaving time for adequate critical discussion, which should be one of the chief functions of our program meetings. In general, not more than fifteen minutes, including discussion, will be allotted any one paper.
2. Organize significant features on slides, films, or in mimeographed form for distribution.
3. Do not send in a title unless you expect to be present to read your paper.

JOHN R. KUEBLER, *Local Secretary*,
for the Indianapolis Meeting,
5503 E. Washington Street,
Indianapolis, Ind.

R. A. BAKER, *Secretary*,
College of the City of New York,
17 Lexington Avenue,
New York, N. Y.

SOME INTERNATIONAL PROBLEMS OF CHEMISTS*

GUSTAVUS J. ESSELEN, 73 NEWBURY STREET, BOSTON, MASSACHUSETTS

It is a commonplace saying that science is international and as an abstract statement most chemists would be inclined to agree with it. The majority of our personal contacts, however, are regional or national in character rather than international, and one cannot help be interested therefore in observing the reactions of one hundred and seventy-six chemists as they meet in an international conference representing twenty-four nations of Europe, North and South America, Australia, and Japan, but with the conspicuous absence of Russia. Right at the outset one big problem forces itself on our attention and that is the political one. To discuss it in any detail, however, would lead us so far astray that we must be content at this time with mere recognition that it exists. Indirectly, however, it had a bearing on the place chosen for the two international chemical meetings which were held in Liége in September. The year 1930 marks the one hundredth anniversary of the independence of Belgium and it was fittingly celebrated by holding two World's Fairs, one at Antwerp and the other at Liége. These expositions drew many meetings of an international character to their respective cities. The question naturally arises why, in a country with an area less than that of the two New England states, Connecticut and Massachusetts, should it be necessary to have two World's Fairs. The answer is to be found in the rivalry between the Flemish and French sections of Belgium. This was well illustrated by the reception to the delegates offered by the burgomaster at the Hotel de Ville in Antwerp. After an unusually appropriate speech in French, he felt it necessary to repeat it in Flemish.

* Presented before the Northeastern Section, American Chemical Society, Boston, Massachusetts, November, 14, 1930.

Note: The material for this paper was suggested by attendance at Le Dixième Congrès de Chimie Industrielle at Liége, Belgium, September 7–13, 1930; and at Le Dixième Conférence International de Chimie of the International Union of Pure and Applied Chemistry, September 14–20, 1930.

Of the two conferences, that of the International Union of Pure and Applied Chemistry, which came the second week, was by far the more important. Its business and technical sessions were delightfully interspersed with social events. In fact the meeting really opened on Sunday with a reception to the delegates and their families.

The International Union of Pure and Applied Chemistry is organized into a Bureau, a Council, and a body of delegates. The Bureau is composed of the vice-presidents and the past presidents. To form the Council, each nation is entitled to a certain number of councilors, the number varying with the country, and in addition each nation is entitled to send a certain number of delegates. These delegates are supposed to attend the meetings of the Council and can take part in the discussions but the vote of any particular country is counted only as the number of councilors. DR. CHARLES L. REESE of the du Pont Company is the American vice-president of the Union.

The first meeting of the Council was quite dramatic. It was the first one since the war at which the Germans were to be present but, when the meeting was called to order, there were no Germans. This excited much comment until some one pointed out that the Germans could not very well attend until a formal motion was passed admitting them. With this detail attended to, two of the members were sent to find the Germans but after much searching they returned without success. Finally, about half an hour later, the German delegation arrived, evidently after much hurrying on their part. A spontaneous round of applause burst out to greet them. In acknowledging this cordial greeting, PROFESSOR FRITZ HABER explained, on behalf of the German delegation, that the day before had been election day in Germany and that the German delegation had started as soon as they could

A GROUP OF AMERICAN DELEGATES TO THE TENTH MEETING OF THE INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY, LIÉGE, BELGIUM, SEPTEMBER 14–20, 1930

(*Left to right*): Alexander Silverman, Edward Bartow, Austin M. Patterson, Charles L. Reese, Claude S. Hudson, J. V. N. Dorr, William Lloyd Evans, Marston T. Bogert, and Joel H. Hildebrand.

after voting, but had been unable to reach Liége any sooner.

One of the earliest problems which arises when chemists from all over the world meet together is that of language. For those who live in Europe where there is frequent opportunity for using several languages, this difficulty is not so great. In fact, it was not uncommon to find distinguished members of the Council making a speech in French and repeating it immediately afterward in English and in German. Nevertheless, it is quite true that all of the delegates did not understand all of the languages represented and therefore there had to be certain official languages. These were French, German, and English. The Spaniards, however, seemed to feel that their language was of sufficient importance so that it, too, should be included in the official list. After careful discussion, however, it was finally decided that a communication might be presented to the Union in any language, it being realized that a man would naturally select one which could be understood by his audience. Nevertheless, in order to avoid errors, it was agreed that all reports on administrative questions, all votes, resolutions, and official acts, if not originally formulated in French, should be translated into that language.

It was rather interesting to observe the way national viewpoints came to the front in the discussions at the early meetings of the Council. Each particular national group, apparently unconsciously, was looking at the various questions under discussion primarily from the point of view of how it affected their particular nation rather than from the point of view of what was the best thing for chemistry. On the other hand, it was a situation which was recognized by all and referred to on numerous occasions in informal conversations after the early meetings of the Council. It was only natural therefore that the attitude should gradually change until at

some of the last meetings of the Council, one of the speakers frankly said in open meeting that these matters of interest to the Union should be viewed not from the point of view of what was the best for some particular nation, but rather what was the best for the science as a whole, and it was this attitude which finally prevailed.

It was a matter of concern to some of the delegates that a certain amount of time had to be devoted to subjects which might almost be considered as matters of organization, but, as the president pointed out, it was often well to do this, particularly when such consideration resulted in simplification. This was the case, for example, in connection with the name, which was simplified from "International Union of Pure and Applied Chemistry" to "International Union of Chemistry," which seems to be not only entirely adequate but also more dignified. The question as to where the headquarters of the Union should be was also one which might have presented some difficulties, but it was agreed that the headquarters should be provisionally at Paris, and that the city in which the headquarters should be located should be decided anew by a separate vote every four years.

The set-up of the various international scientific unions had originally been through the agency of the International Research Council, to which they were, in theory at least, responsible. It might perhaps have been foreseen that in any such set-up, the children would sooner or later reach an age of maturity at which they would no longer feel it necessary to be bound by any higher authority. It is true that in recent years the various international scientific unions have practiced a considerable degree of autonomy which has not been disputed by the International Research Council. Recently, however, this latter body has actually modified its constitution to provide for some of the autonomy which has been practiced, and at the meeting in Liége, the Council of the International Union of Chemistry took cognizance of this modification and interpreted it for its own situation.

It is of course obvious that there are a number of fundamental questions of international significance which can be handled by an International Union of Chemistry to the advantage of chemists all over the world. The machinery for doing this has been to set up a number of international committees to whom these various subjects were referred. The only meetings which these committees had were in connection with the meetings of the International Union every two years, and as it was not always convenient for all of the committee members to be present, it had been the practice for each national delegation to appoint a substitute for any one from their country who happened to be absent. A moment's consideration is sufficient to show the absurdity of any such procedure. The original committee members were always chosen because they were specialists on the subject to be handled by the committee and the chances were that the substitute might know very little about the matter. A vote was passed, therefore, which limited the attendance at the meetings of any committee to the actual members of the committee, it being understood that the real work of the committee would be done by correspondence. At the same time, the actual membership of all the various international committees was scrutinized, and in some instances the membership of these committees was largely revised. This of course is a healthy thing to do now and then in any organization.

Any one at all familiar with chemistry recognizes that one of the most serious problems which confronts our profession is that of nomenclature. For this reason, there have been several standing committees of the International Union having to do with this fundamental subject. One of these had to do with inorganic chemical nomenclature; a second with organic nomenclature; and a third with biological chemical nomenclature. It will readily be seen that this matter of nomenclature may

be handled in several ways and the success of the efforts of any such committee will depend largely upon the way it is handled. One way is to pay no attention to what has been the accepted practice but to start fresh and build up a logical, though entirely new, system, accepting only such part of the previous usage as fits into the new scheme. A second way of proceeding, on the other hand, would be to accept all of the reasonable usage which has developed in the past and to build with that as a basis. This incidentally has been essentially the plan of the committee on organic chemical nomenclature which has been able to accomplish considerable good. Incidentally, the American representative on this committee, PROFESSOR AUSTIN M. PATTERSON, is recognized as an authority in this field.

Another matter of obvious international interest is that of atomic weights. There had previously been a standing committee of the Union on chemical elements. At the meeting in Liége, this committee was sub-divided into three committees. The first of these is an International Committee on Atomic Weights whose duty it will be to publish an annual table of atomic weights to supplant the several national tables previously published. The vote establishing this commission was as follows:

> This committee will be made up of a limited number of members in order that it may be possible to present its annual report without undue delay.
>
> The committee shall serve for six years.
>
> Its members shall be scholars who are not only competent but of unquestioned authority. This double consideration shall decide their choice regardless of their nationality.
>
> They shall establish the annual table with absolute authority and they shall communicate it to the various national organizations so that it may be published in the scientific journals.
>
> The international table shall contain those values for the atomic weights which are considered by the committee to be the most accurate.

The committee appointed consisted of PROFESSOR GREGORY P. BAXTER, PROFESSOR OTTO HÖNIGSCHMID, DR. RICHARD MEYER, DR. PAUL LEBEAU, and MADAME MARIE CURIE. PROFESSOR GEORGES URBAIN, of Paris, had been chairman of the previous Committee on Chemical Elements for so long that he was made the honorary chairman of this new committee.

The second sub-division of the former Committee on Chemical Elements is an International Committee on Atoms which will be chiefly concerned with isotopes and atomic structure. The third sub-division is a Committee on Radioactive Constants to coöperate with the Radium Standard Committee, an international committee outside of the Union.

The matter of uniform physico-chemical symbols and of fundamental thermo-chemical data are also matters which are being studied by separate international committees of the Union and each of these committees made progress reports at Liége. The subjects which the reorganized committee on thermo-chemical data proposes to study are the following:

(*a*) A proposition to introduce salicylic acid as a secondary thermo-chemical standard.

(*b*) A proposition to consider the establishment of a standard for the determination of the heat of combustion of gases and vapors.

(*c*) A study of the bases for calculating the heats of formation of substances containing carbon and hydrogen. In this connection, the committee issued a general invitation to thermo-chemists to undertake new determinations of the heat of combustion of graphite and of diamond in order to confirm the values found by PROFESSOR W. A. ROTH.

(*d*) A reconsideration, in the light of recent work, of the definite choice of the heat of combustion of benzoic acid as a thermo-chemical standard.

Another activity, and one which is of direct interest to us in America is that of the Committee on Tables of Constants. Among other actions taken by this committee was a vote of congratulation to the National Research Council of the United States on its completion of the International Critical Tables and an expression of the hope that in the near future a revised edition or supplementary volume might be undertaken.

It appears that the matter of adequate abstracts is one which has been considered at previous meetings of the International Union. We, in America, are so fortunate with our own *Chemical Abstracts* that this problem perhaps does not seem so important to us as to some of the other nations. A majority of the delegates, however, seemed to feel that some form of unification of chemical abstracts was desirable. The chairman of the American delegation, Dr. Charles Reese, pointed out that this matter had been very carefully considered by the editorial staff of *Chemical Abstracts* in conjunction with editors in other countries, and it was felt that, in this case at least, the various national points of view were so at variance with one another that a proper scheme of unification would be almost impossible of attainment. In spite of this, however, the view finally prevailed that certainly nothing could be accomplished if no attempt were made and therefore a committee of four, representing England, France, Germany, and the United States, was appointed to consider this matter.

It will be recalled that although there have been frequent meetings of the International Union of Chemistry, particularly since the War, there has been no real International Congress since the one which was held in New York in 1912. After considerable discussion it was finally voted that the Union would hold the Ninth International Congress of Pure and Applied Chemistry in Madrid between the 15th of April and the 15th of May in 1932. This leeway was allowed the committee in charge in order that the most satisfactory time might be selected, but it is understood that the Congress itself will last only five days. It is to be open to all nations and is to include all of the various phases of chemical activity. The matter of subdivisions is being left entirely with the Spanish committee of organization. It is also the intention to so organize the program that there will be ample time for discussion of the various papers, it being the plan to have a number of papers by invitation and only a limited number of other papers.

McGREGORY HALL OF CHEMISTRY AT COLGATE UNIVERSITY

R. C. ROBERTS, COLGATE UNIVERSITY, HAMILTON, N. Y.

The erection of McGregory Hall of Chemistry on the campus of Colgate University brings to mind the beginnings of chemistry in the college. A search of the minutes of the Board of Trustees gives a good idea of the way things were done in an earlier day. The following paragraphs are taken from these minutes:

June 20, 1882. *Resolved:* that DR. DODGE, SAMUEL COLGATE, and A. S. BICKMORE be and hereby are appointed a committee to take into consideration the building of a laboratory and endowing a chair in Chemistry and other things in connection therewith, and that said committee report at the next meeting of this Board. (*The minutes do not show any lapse of time between the appointment of the committee and its report*). The Committee appointed at the last meeting of the Board to consider a building of a Laboratory and the endowing of a special department of Chemistry respectfully report:

1. That toward the erection of said building COL. MORGAN L. SMITH will contribute the sum of $5000, REV. DR. DODGE the sum of $2500, and MR. SAMUEL COLGATE the remaining amount needed, $2500—on condition that an endowment of $30,000 be secured for said Professorship of Chemistry.

2. The committee recommended to the Board that the Treasurer be appointed to raise said endowment.

June 19, 1883. *Resolved:* that the time is come in the history of Madison University when a separate department in Chemistry be established. The resolution was adopted.

Resolved: that JOSEPH F. MCGREGORY of Amherst, Mass., be and is hereby appointed professor of Chemistry in Madison University.

Secondly, that his purpose to pursue for another year his studies in Germany be approved by the Board.

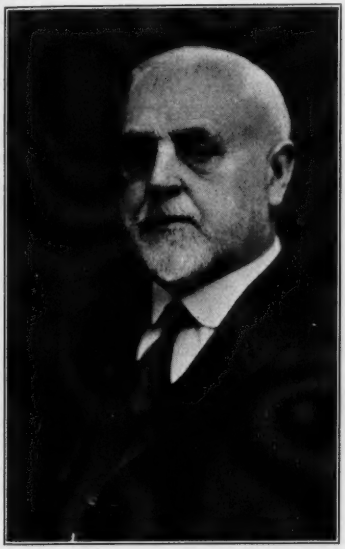
Thirdly, that the Board will expect Mr. McGregory to enter on his duties at the opening of the Academic year in 1884.

Fourthly, that his salary be $1600 per year, to begin Sept. 1, 1884. Carried.

Resolved: that the Board of the University authorize the erection during the coming academic year of a suitable Laboratory for Physics and Chemistry not to exceed in cost about $10,000—and that PROFS. OSBORN and TAYLOR, with the president be a committee to select a site, to deter mine on the place and to carry that plan into execu tion.

On motion DR. P. B. SPEAR was added to the above committee.

This is the record then of the original building erected in 1884 to which an addition was made in 1906, which doubled the size of the laboratory. It was in this build-



JOSEPH FRANK MCGREGORY

ing that PROFESSOR J. F. MCGREGORY spent the years from 1884 to 1929 as professor of chemistry and head of the department. A tribute to his work and influence has already been given by one of his former students and colleagues.*

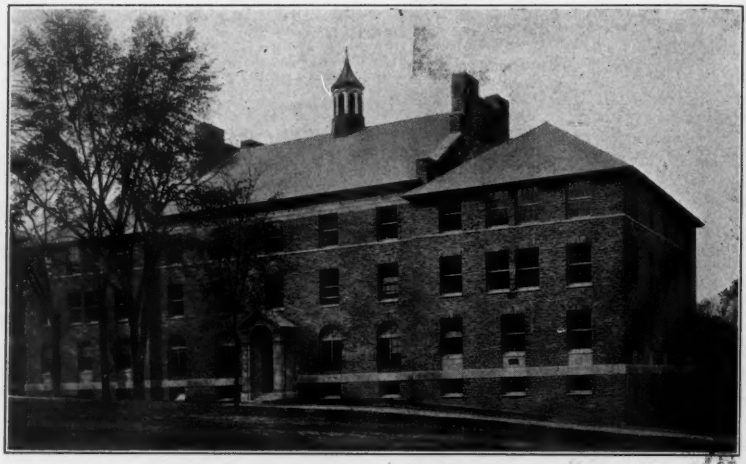
One hundred years ago, a group of devoted men with little money and less knowledge of science but with an abundant evidence of zeal organized among the Chenango Hills of New York State a country college and theological seminary to train men for the Baptist ministry. They brought together a small faculty of zeal similar to their own, men of stirring personality and fervid religious thinking. In those days there was little science anywhere, and even a half century later what science there was had hardly affected the limited curriculum of this institution. But the men of zeal upon whom rested the responsibilities for progress in this little college were in the main broadminded and far-seeing individuals. As scientific knowledge expanded and the efficacy of the scientific method was recognized, science took its place in the courses of study, and for the small group of students, numbering up to the last decade of the nineteenth century less than two hundred, the majority of whom were preparing for the ministry, there came gradually an opportunity to get a glimpse of the wonderland of science. One of the presidents especially had a broad outlook and courageous spirit. He gave of his private means to make a chemical laboratory possible in which the mind of the young minister and of other students beginning to show themselves in the college could be opened to the mysteries and wonder of this great and promising field of study. To Ebenezer Dodge there never could be a clash between religion and science. He prayed for and worked for and encouraged his faculty to pray for and work for that vaster knowledge, always with the unshakable confidence that "mind and soul according well" would ever make "one music."

This is where Professor McGregory comes in. There could not have been a better choice of a man for the situation and the opportunity at Madison University in the early eighties. He came in 1884 fresh from his studies in Germany. He brought enthusiasm for a great subject, and energy to make his enthusiasm take a real form in the permanent progress of the department and the college. He had the inspiration of great teachers—WÖHLER and VICTOR MEYER in chemistry, KLEIN and ROSENBUSCH in mineralogy. But Professor McGregory brought to Madison University more than fresh enthusiasm, boundless energy, and accurate knowledge. He was born to teach. He had a magnetic personality and an understanding sympathy. He comprehended the mental difficulties of the undergraduates and the struggles that were made to overcome them. His was the kind of character which could stand the test of intimacy. Familiarity breeds only respect when the intimates are of the McGregory type. In the days of those small classes at Madison University close association of enthusiastic and admiring students with this man, working single-handed to build a department of science, was permitted and invited. There is no teaching superior to that. When disciple and teacher talk over their subject with the same freedom and intimacy with which they talk about the ordinary relations of life, the disciples learn their subject and many other important things.

Those were the days of individual recitations—quizzes, we called them. They were dreadful experiences, those quizzes. How we worked! A single simple laboratory experiment, or a lecture accompanied by superb demonstrations (Professor McGregory was a master at that) required broad reading if the succeeding quiz was to result satisfactorily. Scattered over this country today are college professors of chemistry, state chemists, industrial chemists, and teachers of chemistry in secondary schools who date their first ideas of the value and importance of perusing chemical literature from Professor McGregory's oral quiz methods. Our educational system, and especially the college part of it, will never see improvement in that sort of pedagogy. Large instructional groups have almost completely removed it from the experience of the modern undergraduate, much to his disadvantage. It is not the grand total of student attendance that is a menace to the high quality of college work, but the size of the instructional group. Obstacles are now in the way of the intimate personal contact with a professor. Large laboratory groups follow cookbook recipes for reactions, and there are other influences which tend to reduce to a mechanical process the fine art of teaching. All these things cheapen the process and the products of teaching. College authorities can do nothing better for the undergraduate than to put him, especially in his freshman and sophomore years, under the admirable and inspirational teaching of the McGregory kind.

This is written in the past tense, as if it were all over. That is far from the fact. Some of it is in the past. Madison University is now Colgate. A student body of less than two hundred is now over seven hundred. A little chemical laboratory of four or five rooms, one of which was devoted to physics, is now a well-equipped, expanded building with separate apartments for each branch of the science. The chemical faculty of one man is now a departmental faculty of six men. These are gratifying evidences of progress, but the most satisfactory thing about the chemistry department at Colgate to students of the past and the present, as well as to those men everywhere who

* EDWARD ELLERY, "Joseph Frank McGregory. An Appreciation," *Ind. Eng. Chem.*, **16**, 530 (1924).



are interested in the development of chemists, is the fact that Professor McGregory is still there, and teaching.

At commencement in June, 1929, the first ground was turned on the place chosen for the site of McGregory Hall. Several years study of plans of other laboratories and the development of features especially required for the local situation had been made preceding this event.

During the summer of 1930, the department was moved from the old laboratory into the new one. Classes and laboratory sections were held for the first time in McGregory Hall in September, 1930.

Dedication

The formal dedication of McGregory Hall occurred December 5 and 6, 1930. Delegates from thirty-four universities, colleges, and scientific societies came to Hamilton to spend the better part of two days as guests of the university.

The formal program began on Friday the 5th at 2.00 P.M., following the academic procession to the lecture room in McGregory Hall. PRESIDENT GEORGE BARTON CUTTEN of the university opened the program by paying a beautiful tribute to the memory of MISS MARY EVELYN COLGATE, who, by the terms of her will, provided the original gift toward the erection of the laboratory. To this sum, her parents DR. and MRS. JAMES C. COLGATE of New York, added the funds necessary to complete and fully equip the structure. President Cutten paid a similar tribute to the long and faithful career of Professor Joseph Frank McGregory, who has headed up the work in chemistry from its beginning through a period of forty-five years.

The first speaker on the program was DEAN EDWARD ELLERY of Union College, an alumnus of Colgate and a former member of the staff of the department of chemistry. In a brilliant and happy address, Dean Ellery gave a historical account of "Chemistry at Colgate," linking up the local development with that of the subject throughout the world during the past half century. He made many interesting and complimentary references to his former teacher, whose presence on the platform beside him added to the joy of the tribute.

The dedicatory address was then given by PRESIDENT LIVINGSTON FARRAND of Cornell University. Dr. Farrand extended greetings from sister institutions, reminding the audience that it is no longer

true that one institution is envious of the additions obtained by another. "Everything that aids in the development of one assists in the development of all." He congratulated the university on naming the laboratory for one who has served the institution so long and faithfully. Then drawing illustrations from his varied experiences as administrator, educator, physician, and public health worker, Dr. Farrand made a plea for coöperation between the sciences. He showed how interdependent the sciences are, how necessary it is that their work be integrated. "It behooves us to see that we exercise toward our problems of human relationships, of economic values, of the maladjustments of society, the same probing mind, the same recognition of truth, when found, that characterizes the science of chemistry. To the advancement of that age of human welfare, McGregory Hall is dedicated."

At 6.30 P.M., the dedication dinner for the delegates, university trustees, and invited guests was held at Colgate Inn. Following the dinner, every one returned to McGregory Hall for a public address by DR. HARRISON E. HOWE, on "Chemistry Re-making the World." Making use of his modern, magic, black bag, Dr. Howe gave many interesting illustrations of the present-day uses of chemistry. He was introduced by his friend of many years, Dr. J. F. McGregory.

The program for Saturday was started with a complimentary breakfast at the College Commons given by Alpha Nu chapter of Alpha Chi Sigma.

The rest of the morning was spent in a conference on chemical education, at which DR. R. C. ROBERTS, head of the department, presided. DR. NEIL E. GORDON, editor of the JOURNAL OF CHEMICAL EDUCATION, gave the first address on "Chemical Education for Teaching and Research." He told of the origin of the Division of Chemical Education, and made a strong plea for coöperation between chemists, as well as other scientists, in developing educational methods and courses in chemistry. He also gave an intimate outline and view of the work being done at The Johns Hopkins University in the selection and training of men for chemistry under its new fellowship plan.

"Chemical Education for Medicine" was the subject of the address by DR. WALTER R. BLOOR, associate dean of the School of Medicine and Dentistry of the University of Rochester. Dr. Bloor indicated the difficulties and intricacies of medical training, the necessity of sound training in the pre-medical years and the dependence of modern medicine on chemistry. He made a strong plea for more thorough training in chemistry especially, so that the student would be the better able to solve the problems of medicine.

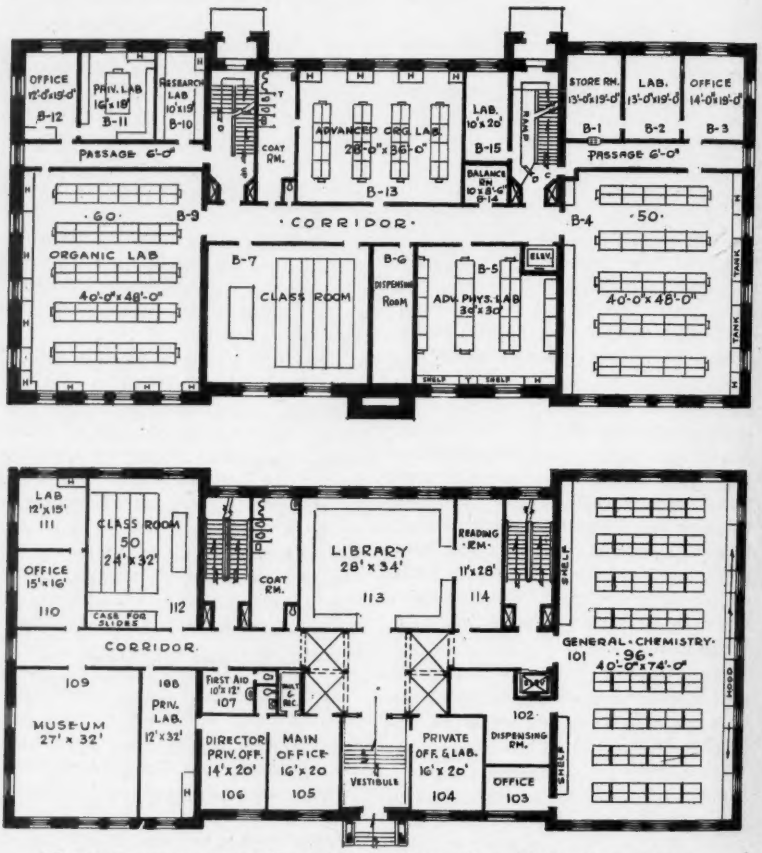
The closing address of the conference and of the dedication program was given by DR. EDWARD R. WEIDLEIN, director of the Mellon Institute of Industrial Research, on "Chemical Education for Industry." Dr. Weidlein pointed out the qualifications necessary for a successful career in industrial chemistry, giving many examples in connection with the work of the Institute to prove his point. He stressed the importance of better training in chemistry, the necessity of a knowledge of economics, the ability to use the English language, an agreeable personality and last but not least, the necessity of hard, painstaking work.

The New Laboratory

McGregory Hall is a fire-proof, five-story building. It has a steel frame construction with none of the stone walls acting as bearing walls. The stone was taken from the university quarry and is trimmed with Bedford stone. The partitions are all of hollow tile with the corridors and all laboratory walls of a special chemically resistant tile. The offices and classrooms are plastered. On the concrete floors, a special composition floor covering has been laid.

There are laboratories for all the usual courses given in college, as well as a number of special rooms fitted up for research and other uses. These laboratories are

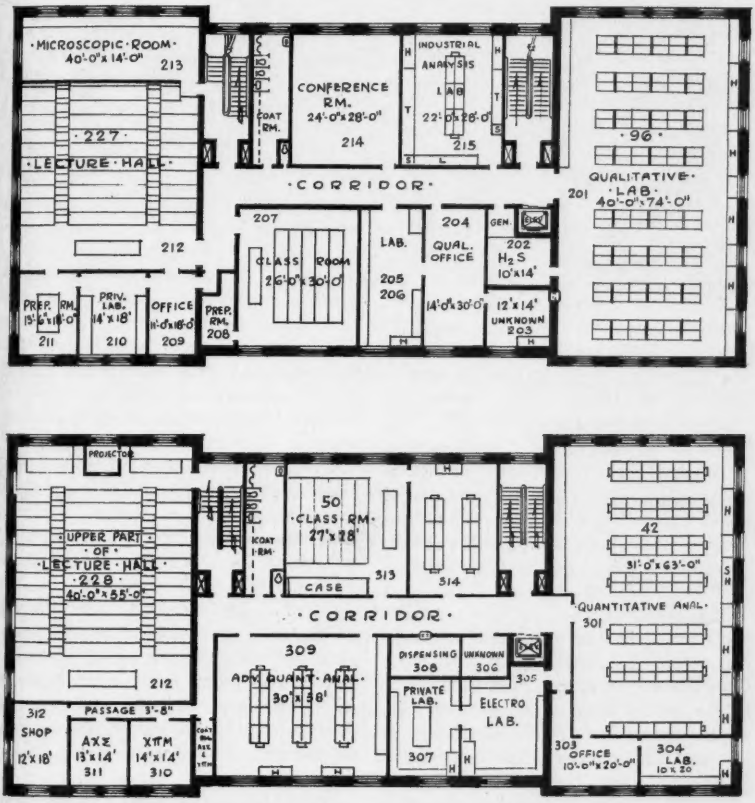
supplied with gas from a Matthews gas machine which is an automatic electric one; with compressed air, hot and cold water, A. C. and D. C. from a special installation furnished by the Standard Electric Time Co. A large lecture hall seating 236 men with four small class rooms seating about 45 men are found in the building.



(*Upper*) BASEMENT PLAN, (*Lower*) FIRST FLOOR PLAN, MCGREGORY HALL OF CHEMISTRY, COLGATE UNIVERSITY

The sub-basement is devoted mostly to storage and service rooms, although dark rooms, a constant temperature room, museum, first-aid room, and a large laboratory for general chemistry. The second floor comprises the large lecture hall at one end with the laboratory for qualitative analysis at the other end. There are also special laboratories, a con-

ference room, and two offices and private laboratories on this floor. The third floor is used for the work in quantitative analysis with one end of the building taken up by the upper part of the large lecture hall. On this floor two rooms are set aside for an automatic steam still for distilled water, which is piped throughout the building in block tin pipes, and twenty-six motors connected with blowers which take care of the hood ventilation in the various laboratories. The ducts from these hoods



(*Upper*) SECOND FLOOR PLAN, (*Lower*) THIRD FLOOR PLAN, OF COLGATE UNIVERSITY'S NEW CHEMISTRY BUILDING

the use of Alpha Chi Sigma, national chemical fraternity, and Chi Pi Mu, a local fraternity, composed of students expecting to study medicine.

There is a full-sized attic in which can be found the room for the machinery of the electric elevator serving all the floors, are of tile until they reach the attic floor where they are made of Alcumite, a special fume-resisting alloy. The motors are all operated by remote control switches located conveniently in the laboratories.

Each large laboratory is served by its own dispensing room in this building.

Student help is necessary for this dispensing service and this arrangement was made to take advantage of that necessity. The dispensing rooms are stocked from the larger stockrooms located in the sub-basement.

Visitors to the building have commented on the fact that plenty of room has been allowed for those who have to work in the building. It was felt that better work could be obtained if there is no crowding and this idea has been carried out quite successfully throughout the entire structure.

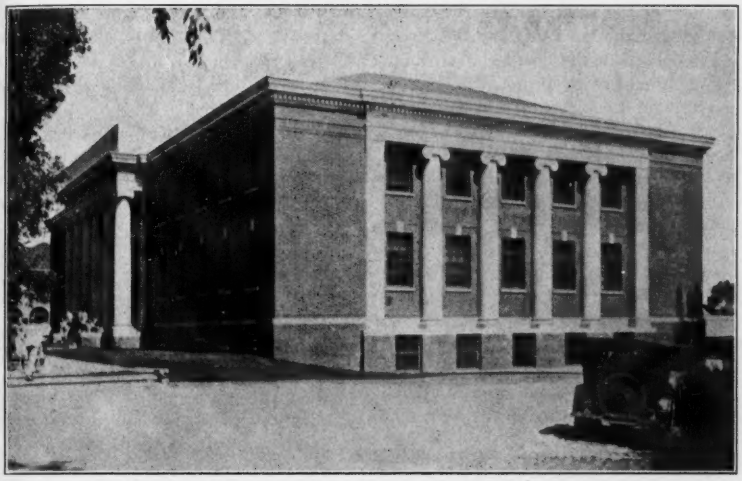
DEDICATION OF MACKAY SCIENCE HALL, UNIVERSITY OF NEVADA

The dedication of the new Mackay Science Hall at the University of Nevada took place on October 24, 1930. The cornerstone was laid by MR. CLARENCE H. MACKAY, who presented the building to the University in memory of his father, John W. Mackay, a pioneer in the development of the state of Nevada. Addresses were made by Mr. Mackay, EDWARD A. DUCKER, chief justice of the Supreme Court of Nevada and chairman of the honorary board of visitors of the University of Nevada, WALTER E. CLARK, president of the institution, and JUDGE GEORGE S. BROWN, chairman of the board of regents.

The building is to house the departments of mathematics, physics, and chemistry. The department of chemistry occupies all three floors of the north wing. The main lecture room is located immediately in front of the entrance to the building and has seats for one hundred eighty students. The tablet arm chairs are placed on risers arranged in a circular form so that the lecture table is clearly visible from all positions. Light enters the room from skylights, fitted with shades for darkening the room. The lecture table is lighted by means of two shell reflectors located in the ceiling and operating from the table. It is equipped with outlets for both alternating and direct current, gas, water, vacuum, and compressed air. A removable glass fume hood is also provided, the exhaust from which is connected with the ventilating system of the room and operated by remote control from a switch near the lecture table. A small lecture room, accommodating about forty students and arranged in a similar manner, is situated just south of the main entrance. Adjacent to the main lecture room is a small preparation room and a small storeroom for lecture apparatus. Two recitation rooms and the department library are located on the second floor.

The main laboratories for regular class work are grouped together in the north end of the building in such a way that students working in them have easy access to the distribution room situated on the first floor. The laboratories in the basement and on the second floor are served by a dumb waiter operated between the distribution room and these floors. The plan has been to provide a number of small laboratories accommodating a single class instead of grouping a larger number of students together under the direction of two or more instructors. The laboratories, therefore, for general, analytical, and organic chemistry are arranged to accommodate twenty-four students each, working at the same time. Those for general chemistry and qualitative analysis are situated on the basement and first floors and provide space for a maximum of three hundred thirty-six students. Each student is provided with gas, water, suction pump, desk fume hood, and reagent shelves, so that the need for leaving his desk during a laboratory period is reduced to a minimum.

The laboratories for quantitative analysis and organic chemistry are situated on the second floor and are provided with large fume hoods, steam drying ovens, steam-baths, and sand-baths. In addition to these, which are for general use, each student is supplied with gas, water, steam, vacuum, compressed air, and electricity. A steam-cold water mixing faucet located over the sink at the end of each desk provides hot water for these laboratories.



Those for quantitative analysis are provided with individual balance cases containing small tubular lamps for lighting the balances. The laboratory for physical chemistry occupies the northwest corner of the second floor and is fitted with outlets for both alternating and direct current and a constant temperature bath in addition to the gas, water, steam, etc., furnished to all laboratories.

In addition to the laboratories for quantitative analysis, organic and physical chemistry, three small laboratories for advanced work and research, two office laboratories, a dark room, and Kjeldahl digestion room are situated on the second floor. One laboratory for advanced students, the department offices, and two private laboratories are located on the first floor. Large store rooms, a grinding room, shop, hydrogen sulfide room, and furnace room are located in the basement. Although no industrial chemistry laboratory work has yet been attempted by the department, one large basement laboratory has been reserved for this purpose when the need arises.

The *University of Nevada Bulletin*, **24**, No. 5 (December 1, 1930), which has furnished the above description of the chemistry quarters of the new building, contains a number of illustrations of the structure, an account of the dedication ceremonies, the addresses on that occasion, and a history of the development of the physical sciences at the University of Nevada.

PURDUE RESEARCH FOUNDATION

Rapid development of research work at Purdue University in connection with the industrial growth of the state was emphasized with the filing of articles of incorporation of the Purdue Research Foundation. The organization of the foundation marks another epoch in the influence of the university and gives a new impetus to the extensive research program of scientific research.

The foundation is a non-profit organization and has no capital stock. Its purpose is to assist in the financing of the research projects and handling of matters pertaining to inventions and patents for the benefit of the state at large, the university and industrial organizations directly concerned.

Calls upon the university by industries of Indiana, especially during the last few years, for assistance in solving scientific problems vital to their growth have increased with the growing economic im-

portance of the state in national affairs. Recognizing the need for more constructive coöperation, the board of trustees of the university in 1927 authorized organization of a special department to handle research relations with industry. MR. G. STANLEY MEIKLE, a well-known consulting engineer, was chosen director of the newly created department. As a result of his work, direct coöperation between industry and the university has grown rapidly. This has led to the organization of the foundation to assume the legal and financial responsibilities of the rapidly expanding research program.—*Science*

MORE POWERFUL RADIATIONS FORESEEN AS 30,000,000 VOLTS ARE PREDICTED

Aspiration to duplicate in the laboratory the powerful radiations that hitherto have been produced only by nature promises to lead to further discoveries by the trio of Carnegie Institution physicists whose paper on high voltage tubes won the $1000 prize of the American Association for the Advancement of Science at Cleveland in December last. Within the realm of possibility of accomplishment in the near future is the production of voltages of twenty to thirty million.

At present the vacuum tubes developed by DR. M. A. TUVE, DR. L. R. HAFSTAD, and ODD DAHL in the laboratories of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington have operated reliably at potentials up to two million volts. This is a remarkable potential to be impressed upon a vacuum tube and it produces the most powerful radiations yet made by man, artificial beta rays, which are high-speed electrons, and artificial gamma rays, which are very penetrating X-rays. Thus two of the three radiations from radium have already been duplicated.

Dr. Tuve and his associates are now at work on a new method of building up electrical voltages that should soon make it possible to impress upon gigantic X-ray or other vacuum tubes voltages much higher than the five million or so they have generated so far. Thirty million volts are theoretically possible with a modification of what is called the Faraday cage which has been developed.

By using these voltages to accelerate the positively charged cores of hydrogen atoms these scientists will have by far the most powerful projectiles ever available to a human being, resembling the alpha rays from radium. What will happen when they are let loose is still a matter of discussion among scientists.

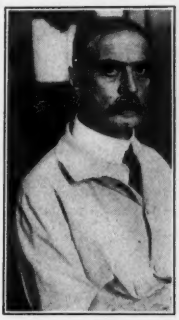
Some physicists have suggested in the past that if such powerful radiations were allowed to smash into the hearts of atoms, there might be a liberation of the immense internal energy of the atoms with a gigantic explosion that would wipe out the world and this corner of the universe.

But most physicists do not expect such a cataclysm. They expect the artificial radiation to be extremely useful in probing more deeply the fundamental structure of matter. They expect as a by-product that the powerful radiations will be useful in the treatment of cancer and possibly put to other medical uses. They expect that the radiations will give new knowledge of the earth's magnetism and how it is caused. This latter possibility was the starting point of the whole investigation and is the reason for its support by the department of terrestrial magnetism of the Carnegie Institution directed by JOHN A. FLEMING. Incidentally, there will also come a better understanding of radio because physicists feel sure that the radio-reflecting Kennelly-Heaviside layer above the earth is affected by natural radiations that come from the sun and outer space.

DR. JOHN C. MERRIAM, president of the Carnegie Institution, expressed delight at the award of the American Association prize to the three members of his institution and explained: "Their work represents a long-continued intensive study of this problem and it is a great pleasure to know of the recognition of the work at this stage of the investigations."—*Science Service*

NOBEL PRIZE TO DR. LANDSTEINER FOR BLOOD GROUP DISCOVERY

Discovery that human blood is of four different types and that blood of one type does not always mix with blood of another type has won the 1930 Nobel prize in medicine for DR. KARL LANDSTEINER of the Rockefeller Institute of Medical Research. The enormous importance of Dr. Landsteiner's discovery has been evident to patients who have had the life-saving operation of blood transfusion performed. For this operation the blood of the donor and that of the patient must mix well, or serious and even fatal results may occur. Consequently before each transfusion, samples of the two bloods are tested or "matched" to see if they are compatible and belong in compatible blood groups.



When the blood liquid of one normal, healthy person and the red blood cells of another are put in the same tube, instead of mixing freely the red cells often agglutinate Dr. Landsteiner observed during the course of some investigations made in Vienna in 1900. When agglutination happens in a man's vein, following blood transfusion, death may result. It did not take place at random, Dr. Landsteiner found, but depended on certain definite properties of the blood. It is on the basis of these properties that blood was divided into different groups or types. Three of the types were discovered by Dr. Landsteiner and the fourth by two of his students.

Every human being belongs to one or the other of the blood groups. To a certain extent, blood groups are inherited, and this fact is often used to determine paternity. If the blood groups of each parent are known, one can state to which group their child might belong.—*Science Service*

SCIENCE ATTACKS PROBLEM OF DRUG ADDICTION

A fundamental scientific attack upon drug addiction has been launched and underway for the past two years, it became known when DR. WILLIAM CHARLES WHITE, chairman of the National Research Council's committee, summarized the progress so far and the promises of future accomplishment.

Instead of treating the unfortunates who have become addicts to morphine or other habit-forming preparations, the group of scientists working on this problem have begun with a thorough investigation of the chemical, biological, and medical phases of the problem.

First, the committee is attempting to replace habit-forming drugs with drugs without addiction properties. Morphine, for instance, is strongly addicting, while codeine, which causes few addicts, can replace many uses of morphine if used in larger doses. Marked progress had been made in recent years in the replacement of cocaine by safe drugs in practically all its uses except application for surface anesthesia. This gave the committee hope that substitutes for other habit-forming drugs could be found and the national and international control of the manufacture, handling, and sale of narcotics made easier.

With the coöperation of the American Medical Association, the committee plans to furnish physicians with information on the latest discoveries of how non-habit-forming drugs can be substituted for those that are likely to cause addicts.

To discover narcotic substitutes two research laboratories were established, one at the University of Virginia for chemical analysis and synthesis of alkaloid substances and the other at the University of Michigan for the biological testing of the narcotics and their substitutes.

The National Research Council committee has also worked closely with the U. S. Public Health Service and the Treas-

ury Department Narcotic Bureau. The funds for the work have been provided by the Bureau of Social Hygiene, Inc., of New York City, of which LAWRENCE B. DUNHAM is director.

Because few American chemists had worked on alkaloid chemistry in the past twenty-five years, it was necessary to import chemists from Europe for the staff of the University of Virginia laboratory, which has been directed by DR. L. F. SMALL, an American who had spent two years in narcotic research in Europe. Dr. Small and two colleagues, DR. ERICH MOSETTING and DR. ALFRED BURGER, from the laboratory of PROFESSOR ERNEST SPÄTH, in Vienna, are now training American chemists to carry on this work. They have made thirty compounds for testing by the University of Michigan laboratory in charge of PROFESSOR C. W. EDMUNDS and DR. NATHAN B. EDDY.

Members of the National Research Council's drug addiction committee include: DR. WILLIAM CHARLES WHITE of the National Institute of Health, *chairman;* DR. C. S. HUDSON of the U. S. Bureau of Standards; DR. F. B. LAFORGE of the U. S. Department of Agriculture; DR. WALTER TREADWAY of the U. S. Public Health Service; DR. CARL VOEGTLIN of the National Institute of Health; DR. TORALD SOLLMANN of Western Reserve University School of Medicine; DR. REID HUNT of Harvard University School of Medicine; and H. J. ANSLINGER, U. S. Commissioner of Narcotics.—*Science Service*

CHEMICAL MAP OF NORTH AMERICA

A chemical map of North America, the first attempt of its kind to show the wide range of sources of medicinal chemicals, has been prepared by PROFESSOR H. V. ARNY, dean of the College of Pharmacy, Columbia University, and E. L. NEWCOMB, secretary of the National Wholesale Druggists Association. The map, in five colors, represents all countries from the Panama Canal Zone to Hudson Bay. Names of ores, minerals, chemicals, and elements appear approximately at the point of origin. Countries, states, and provinces are shown in yellow; oceans and lakes in blue; political boundaries and important cities in red; mountains in sepia, and rivers and most type matter in black. In the border are photographs and sketches of mining operations and chemical plants. —*Science*

OUTSTANDING EDUCATORS WILL PICK BEST ARTICLES ON EDUCATION

America's leading specialists in education will select the most important articles published in their respective fields for the Office of Education's "Record of Current Educational Publications," according to an announcement made by WM. JOHN COOPER, United States Commissioner of Education.

For eighteen years the record of the most important articles in seventy-nine different phases of education has been prepared in entirety every three months by the library of the Office of Education. Now the seventy-nine phases of education covered have been divided into fourteen major groups. An outstanding specialist in each of these fourteen fields has been invited to submit quarterly a list of the notable articles in his particular field appearing in educational magazines, important books, reports, proceedings, and other publications.

The educators who have offered to help the Office of Education make the "Record of Current Educational Publications" a highly selected list of best thought in the educational press, and the sections on which they will report are: DR. ARTHUR J. KLEIN, professor of school administration, Ohio State University, Columbus, Ohio, who will submit articles published in the field of Collegiate and Professional Education; DR. W. C. EELLS, associate professor of education, Leland Stanford Junior University, Stanford University, California, Junior College; DR. L. V. KOOS, professor of secondary education,

University of Chicago, Chicago, Illinois, Secondary Education; DR. ERNEST HORN, professor of elementary education, State University of Iowa, Iowa City, Iowa, Elementary Education; MISS EDNA DEAN BAKER, president of the National College of Education, Evanston, Illinois, Nursery-Kindergarten-Primary Education; DR. CARTER ALEXANDER, professor of education, Teachers' College, Columbia University, New York, N. Y., Public School Administration; DEAN M. E. HAGGERTY, School of Education, University of Minnesota, Minneapolis, Minn., Educational Psychology; DR. E. S. EVENDEN, Teachers' College, Columbia University, New York, N. Y., Teacher-Training; EDWIN LEE, director of the division of vocational education, University of California, Berkeley, California, Vocational Education; ALONZO G. GRACE, assistant director of the division of extension teaching, University of Rochester, Rochester, N. Y., Adult Education; MISS ELISE MARTENS, specialist in the education of exceptional children, Office of Education, Department of the Interior, Washington, D. C., Education of Exceptional Children; DR. JAMES F. ABEL, chief of the division of foreign school systems, Office of Education, Department of the Interior, Washington, D. C., Foreign Education; DR. AMBROSE CALIVER, specialist in negro education, Office of Education, Department of the Interior, Washington, D. C., Education of Negroes; and MISS MARTHA MCCABE, assistant librarian, Office of Education, Department of the Interior, Washington, D. C., Proceedings, Summaries, Courses, etc.

In adopting this method of collecting data for the Record of Current Educational Publications, the Office of Education expects to produce a list of writings covering completely and qualitatively every branch of education.

ORGANIZATIONS ACT ON EDUCATIONAL SITUATION IN MISSISSIPPI

A resolution adopted on December 29th by the American Association of University Professors meeting in Cleveland declared four Mississippi colleges to be not in good standing so that members may not retain their membership and teach at the Mississippi institutions. The schools dropped were the University of Mississippi, the Mississippi A. and M. College, the Mississippi State College for Women, and the State Teachers' College.

On the same day the Association of American Law Schools dismissed the law school of the University of Mississippi from membership because of the replacement of JUDGE THOMAS C. KIMBROUGH as dean, and a resolution was adopted commending his work.

The medical college at the university had been already placed on probation by the American Association of Medical Schools and the student chapters of the American Society of Civil Engineers had been withdrawn. The Association of American Universities took similar action at Berkeley in October.

The Association of Colleges and Secondary Schools of the Southern States suspended on December 4th the four institutions. Under the terms of the suspension resolution, it will be effective until the association reinstates the schools by vote. The report of the executive committee which was adopted attributed the suspension to "the wholesale dropping of scores of officers and teachers (from the suspended schools last summer) without warning, without charges, and without opportunity of defense." A correspondent of the *New York Times* reports that GOVERNOR BILBO has yielded to the protests of citizens of the state to the extent of permitting the board of trustees of the state institutions formally to rescind its order to the effect that professors and teachers were subject to instant dismissal.—*School and Society*

PROPOSED CHANGES IN SYSTEM AT PHILLIPS EXETER ACADEMY

LEWIS PERRY, principal of Phillips Exeter Academy, announced that funds have been provided by EDWARD S. HARKNESS,

New York philanthropist, making possible changes in its teaching system which will result in important improvements in the methods of secondary education. . . . Under the newly planned system the boys will receive instruction in groups of not more than ten, which "constitute the most effective size for teaching." The announcement states that:

> Any such arrangement as this will permit special teaching in groups of those who have unusual difficulty with a particular subject and also in groups of those boys, who, because of their greater aptness, are able to go ahead faster than the average.
>
> By this method the school hopes to be able to gain better results than those resulting from the old-fashioned form of recitation which has consisted so largely in repeating something which has been memorized.
>
> It is anticipated that these improvements in the method of teaching will enable students from the secondary schools better to meet conditions of college life in the tutorial and house systems which are now being adopted by so many of our leading universities, through providing a sort of school of apprenticeship in some of the essential features of the colleges. . . .

To carry out the projected plan the academy will make additions to its faculty, thus increasing the proportion of teachers to boys. . . . . A new building will be erected in which teaching in small sections can be carried on under suitable conditions.

Provision also has been made "for a fund to enable instructors to obtain sabbatical leaves which will permit them to return to their work after further study and with a more lively interest in teaching."—*School and Society*

AMERICAN ASSOCIATION OF TEACHERS OF PHYSICS

At the Cleveland meeting of the A. A. A. S. an organization was formed for the purpose of promoting and improving the teaching of physics of college and university grade, under the name, "American Association of Teachers of Physics." The new organization fills a need long felt by those interested in methods of instruction, from the pedagogical as well as from the laboratory and demonstration points of view. A tentative constitution was adopted, and an executive committee chosen to perfect plans for the organization, which are to be discussed and acted upon at the New Orleans meeting. Regional as well as general meetings are to be held. The first general meeting is to take place at the Bureau of Standards in April, in connection with the regular meeting of the American Physical Society. At this meeting, DR. A. W. HULL, assistant director of research of the General Electric Company, will present a paper on the training of physicists for industry.

Officers elected for the current year are: *President*, DEAN HOMER L. DODGE, University of Oklahoma; *Vice President*, DR. P. E. KLOPSTEG, Central Scientific Company; *Secretary-Treasurer*, PROFESSOR W. S. WEBB, University of Kentucky. The executive committee consists of the officers and the following members: PROFESSOR O. B. BLACKWOOD, University of Pittsburgh; PRESIDENT K. T. COMPTON, Massachusetts Institute of Technology; PROFESSOR R. S. MINOR, University of California; DEAN F. K. RICHTMYER, Cornell University; PROFESSOR M. N. STATES, University of Kentucky; PROFESSOR B. A. WOOTEN, University of Alabama. Applications for charter membership will be received until June 1, 1931.

AMERICAN CONTRIBUTION TO ROYAL INSTITUTION

The Pilgrim Trust, founded by MR. EDWARD S. HARKNESS, of New York, has made one of its first gifts to the Royal Institution. The trustees have allocated the sum of £16,000 to meet the deficiency on the fund for reconstruction of the building in Albemarle Street (London). In informing the Institution of this grant, the trustees state that in making it they had regard to the distinguished scientific services rendered to the whole community for more than a century by the Royal Institution, and to the approaching Faraday celebrations. They were also not unmindful that the founder of the Royal Institution, Count Rumford, was of American origin. The provision of funds to meet the cost of the extensive program of reconstruction which was forced upon the managers has

been a matter of the greatest concern to them and to every friend of the Institution. It will be recalled that, following a series of alarming explosions in Albemarle Street more than two years ago, the condition of the historic lecture theater from the point of view of fire risks was shown to be such that reconstruction could no longer be deferred. Plans conforming to modern standards of fire protection, including the provision of suitable exits from the theater, proved to involve the rebuilding, not of the theater itself alone, but also of a large part of the structure surrounding it. After the fullest consideration, the work was put in hand at an estimated cost of not less than £80,000; now, as it is rapidly approaching completion, the actual cost is found to be upward of £90,000.

The aim has been to raise the sum required for reconstruction without drawing upon the existing funds of the Royal Institution and thereby crippling the already inadequate provision for research. In this the managers have been successful, and by special measures, and with the generous assistance of private individuals, and of industries which have benefited, indeed in certain cases have their origin in the scientific work at the Royal Institution, they have raised a large fund. This, with the addition of the £16,000 from the Pilgrim Trust, is now sufficient to meet practically the whole cost of the rebuilding. The Institution is thus enabled to enter upon the year of the forthcoming Faraday celebrations and to look forward to a continuance of its work free from immediate financial embarrassment. With the cost of the rebuilding provided for, the managers are free to turn their attention to another pressing object, the endowment of research. Some progress has already been made toward the establishment of a fund for this purpose. In the coming year it is hoped to add considerably to this fund, and thereby to place the scientific work of the Royal Institution and the Davy-Faraday Laboratory on a financial footing which accords with the requirements of modern research.— *Nature*

JUBILEE OF SOCIETY OF CHEMICAL INDUSTRY

Founded in 1881, the Society of Chemical Industry will next year celebrate its jubilee, chiefly by means of proceedings of a domestic character associated with the annual meeting, which will begin on July 13th and extend over the succeeding seven days. It is intended to confer the rare distinction of honorary membership of the Society on a small number of eminent foreign technologists. It is also intended to present inscribed plaques to the original members of the Society and to the prime wardens or masters of such livery companies of the City of London as have specially fostered the education or progress of applied science. In addition to the social engagements appropriate to such an occasion, there will be arranged exhibitions of apparatus and plant and visits to works typical of the manufactures of London. Two special publications are being prepared in honor of the jubilee. DR. STEPHEN MIALL, editor of *Chemistry and Industry*, is writing a comprehensive history of the chemical industry, while a special number of the Society's *Journal* will include reprints of the outstanding papers which have appeared during the fifty years of its existence. The progress of chemical industry and that of the Society itself will be outlined, and use will be made of the opportunity for biography. These publications will be available to the general public, for whose information and interest there are also being arranged a series of broadcast addresses and the distribution of authoritative articles dealing with the relation of chemistry to life and industry.

PRESIDENT OF AMERICAN INSTITUTE OF CHEMISTS HONORED

DR. FREDERICK E. BREITHUT, president of the American Institute of Chemists, Inc., has been elected, *ex officio*, an honorary member of the Chemical, Metallurgical, and Mining Societies of South Africa.

Dr. Breithut has been made professor of chemistry and head of the department of

chemistry of the Brooklyn College of the City of New York.—*Science*

DR. LAMER TO VISIT STANFORD UNIVERSITY

PROFESSOR VICTOR K. LAMER, of the department of chemistry, Columbia University, who is on sabbatical leave from the university where he has taught since 1919, will be visiting professor at Stanford University during the spring session of 1931. He will direct courses in physical chemistry and catalysis. Professor LaMer is a former chairman of the organic division of the American Chemical Society.—*Science*

SUMMER COURSES IN CHEMICAL MICROSCOPY AT CORNELL UNIVERSITY

The department of chemistry at Cornell will offer instruction in chemical microscopy during the coming Summer Session of the University. The equipment of the Baker Laboratory is unique in this field and affords excellent facilities for study of the various microscopic methods applicable to chemical problems or to investigations in allied fields.

The introductory course will cover the theory and uses of the microscope and its accessories, ultra-microscopes, photomicrography, microscopic measurements and quantitative methods, crystal studies and physicochemical phenomena, refractive index determinations, and examination of textile and paper fibers. A course in microscopic qualitative analysis covering the reactions of the commoner metals and acids will also be given. Both of these courses will be the full equivalent of those given during the regular college year; they may be taken separately or together, or other work in the department may be carried on, according to the needs of the student.

The summer session opens July 6th and continues for six weeks, but persons not desiring university credit may arrange to cover, in a shorter period, those portions of the work most suited to their special needs. Any inquiries should be addressed to PROFESSOR C. W. MASON, who will have charge of the courses.

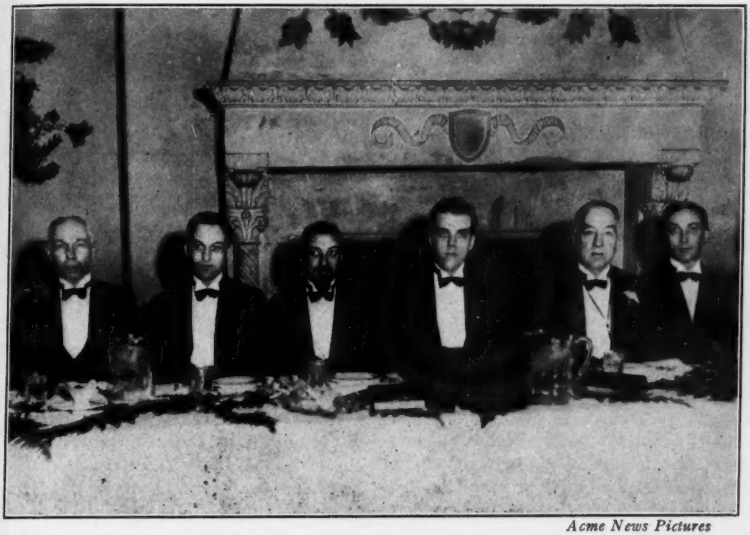
SIGMA XI CHAPTER AT THE UNIVERSITY OF PITTSBURGH

Permission has been granted to establish a chapter of Sigma Xi at the University of Pittsburgh. Formal installation occurred on February 11th, under the supervision of the national president of Sigma Xi, DR. G. W. STEWART, professor of physics at Iowa State University, and the national secretary, DR. EDWARD ELLERY, professor of chemistry and dean of the faculty at Union College.

MEETING OF NEW YORK ALUMNI OF WORCESTER POLYTECHNIC INSTITUTE

An address by PROFESSOR JOHNSON O'CONNOR, consulting psychologist, The General Electric Company, on "The Human Equation in Business—Applying Engineering to the Personal Problems of Employment" constituted the principal feature of the midwinter meeting of the New York Alumni Association of Worcester Polytechnic Institute at the Fraternity Clubs Building in New York City. Professor O'Connor explained his system of test puzzle blocks (*shown in illustration*) in rating industrial personnel on adaptability for various types of work. His experiments represent a scientific attempt to solve the age-old problem of "square pegs in round holes."

The meeting was well-attended, buoyant in spirit, and marked by a program of high excellence. Held during the week of the National Meeting of the American Society of Mechanical Engineers, there was a liberal attendance of members from points geographically remote. Diversely distinguished and interesting, without exception, were those who responded to toasts at the head table. They included: ELMO SUMNER THAYER, New York manager, Falulah Paper Company; JOHN W. BURKE, consulting engineer; DR. S. S. EDMANDS, director of the school of science



Acme News Pictures

H. HORTON SHELDON LEON V. QUIGLEY JOHN JOHNSTON
SAMUEL S. EDMANDS JOHNSON O'CONNOR RALPH EARLE

and technology, Pratt Institute; DR. H. HORTON SHELDON, science editor, *New York Herald-Tribune;* DR. H. B. SMITH, former president of the American Institute of Electrical Engineers; PROFESSOR JOHNSON O'CONNOR; ADMIRAL RALPH EARLE, war-time chief of the Bureau of Ordnance; DR. JOHN JOHNSON, director of research, United States Steel Company; ROBERT T. POLLOCK, consulting engineer; DANIEL L. HUSSEY, Standard Oil Company; DR. SPENCER MILLER, consulting engineer; LEON V. QUIGLEY, technical editor, Bakelite Corporation, as president of the New York Alumni, was toastmaster. Doctor Edmands, who is president of the national body, responded with a word of greeting and resumé of Institute activity. Admiral Earle, now President of Worcester Polytechnic Institute, made an address in which he presented the most interesting phases of the Institute's operation. Enrolment is now at a high level in the New England engineering college, and consideration is being given to the introduction of courses on business administration which hitherto have not been present in the rigid engineering and scientific curriculum.

DEATH OF RICHARD B. MOORE, ISOLATOR OF RADIUM FROM AMERICAN ORES

Radium that he had isolated from American ores aided in the fight to save the life of DR. RICHARD B. MOORE, chemist, who succumbed to brain tumor and double pneumonia at Memorial Hospital, New York City, January 20th.

About half of the million dollars' worth of radium extracted by Dr. Moore's process by the National Radium Institute at Denver, which he directed just before the war, was sent to Memorial Hospital for the treatment of cancer. When Dr. Moore became ill with brain tumor that could not be removed surgically, he came to New York where the powerful radiations of the element he produced could be used in attacking the disease.

While with the Bureau of Mines, Dr. Moore pioneered in the extraction of

helium from natural gas which gave American airships a safe non-inflammable lifting gas. He was chief chemist of the Bureau of Mines from 1919 to 1923. At the time of his death he was dean of science and head of the chemistry department at Purdue University.—*Science Service*

DR. WILLIAMS JOINS STAFF OF BATTELLE MEMORIAL INSTITUTE

The trustees of Battelle Memorial Institute announce the appointment of DR. ROBERT C. WILLIAMS as a member of the technical staff of the Institute.

Dr. Williams is a graduate of Oberlin College where he specialized in colloidal chemistry under DR. HARRY N. HOLMES, and where he later received his master's degree for additional work in this field. He extended his work at Stanford University, securing his doctor's degree at that university.

During the past two years Dr. Williams has been engaged in industrial research with one of the large rubber companies. He joins the Institute staff to undertake a program of research sponsored by industry.

DEPARTMENT CHANGES AT GEORGETOWN COLLEGE

MR. A. G. MOSELEY, JR. (M.S., University of Nebraska), has resigned as assistant professor of chemistry at Georgetown College to take a position at Marshall College, Huntington, West Virginia. The position at Georgetown is being filled by MR. S. A. GORDON (M.S., University of Alabama) of Marion Institute, Marion, Alabama.

FRATERNITY AWARD TO STUDENT AT UNIVERSITY OF AKRON

MR. GUY REYMOND of the senior class of the University of Akron, has been given the annual award of the Delta Epsilon Chi honorary chemical fraternity of the chemistry department of the University of Akron. The award consists of a year's membership in the American Chemical Society and is given to the senior who has attained the highest scholastic average for his first three years in college.

Electrical Eye Separates Metals. Man has been looking at minerals and metals since the first iron that fell from the heavens as flaming meteors attracted the attention of cave dwellers. But not until now has he sought to classify metals by simply looking at them.

Early scientists weighed metals to separate those of different qualities. Then electrical and magnetic conductivities were measured. Later solubility, wettability, crumbleability, and surface tension were means of classification. And just recently the appearance of minerals and metals to an electrical eye has been used to separate one kind from another, according to Prof. Roy W. Drier of the Michigan College of Mining and Technology.

Prof. Drier's apparatus, though experimental, promises to lead to the saving of valuable minerals and metals of industry now wasted. A successful test was made on the separation of silver and copper ores which occur together on the upper peninsula of Michigan. Colored rock salt was satisfactorily removed from the product of the St. Clair valley leaving the white crystals for commercial use.

The apparatus provides for particles of the material under test to fall upon a moving, black, endless belt. They pass under a constant source of light, a part of which is reflected back to a photo-electric cell. Some particles reflect more light than others and thus set up different currents through the cell, which are amplified to operate a mechanical apparatus that removes the material whose reflection index is above or below a certain value.—*Science Service*

Recent Books

Analytical Processes. T. B. SMITH, A.R.C.S., B.Sc., Assistant Lecturer in Chemistry at the University of Sheffield. Longmans, Green and Co., New York City, Edward Arnold and Co., London, England, 1929. viii + 373 pp. 51 figures, 16 tables. 14 × 21.5 cm. $5.00.

The statement is sometimes made that any chemist can carry out a procedure in quantitative analysis who is able to follow directions. Rather than to decry the half-truth in such a stand it is better to substitute for it the following statement. No one can carry out an *intelligible* quantitative analysis who is *only* able to follow directions.

In "Analytical Processes. A Physico-Chemical Interpretation," Smith has supplied the justification for the latter of the two above-mentioned opposite contentions and has effectively emphasized why quantitative analysis procedures should not be considered as merely technical directions. The text is an excellent contribution to the field of quantitative analysis to be used in connection with the teaching of advanced courses of inorganic analysis and as an aid to students engaged in the solution of analytical research problems or other research programs in which analytical factors play a major rôle. This text should appeal to the instructor of elementary quantitative analysis in keeping the minds of the better class of students, whose progress warrants it, supplied with reference material of select and stimulating nature yet not beyond the student's reserve power of assimilation.

The book is divided into two parts with a discussion of approximately twenty typical processes of analytical chemistry. The discussion dealt with in the first part covers the theoretical foundations of these processes and the second part a critical examination of some of these theories. The first part devotes eight chapters or about one-third of the material to gravimetric precipitations and associated operations. Four chapters follow dealing with volumetric applications, with chapter 13 dealing with electro-analysis. Part I is concluded by a chapter on recent advances in a typical gravimetric process—the influence of H-ion concentration on sulfide precipitation.

The last third of the book dealing with a more critical examination of some of the theories employed includes solubility relationships, colloidal phenomena, oxidation and reduction reaction, and complex ion formation. Two short appendixes conclude this volume, one dealing with apparatus for quantitative analysis and the other with indicator data.

The treatment of gravimetric operations involves in the main the application of the von Weimarn coefficient of precipitation velocity and its use in interpreting results from precipitation under different experimental conditions including the formation of colloidal precipitates. The specific examples chosen are the precipitation of barium and lead sulfates and ferric hydroxide. The chapter on ignition of precipitates is to be welcomed and is all too brief. The remainder of part one consists of material the main portion of which can be quite as satisfactorily obtained from a small group of current reference texts and the treatment is not materially different.

The book has been very satisfactorily arranged and is full of indications that the author is fully informed as to the needs for supplementary reading as an adjunct to the study of quantitative analysis as presented in the usual type of textbook on the subject. The only real criticism it seems that can be applied to this text is the fact that it has been so well written that it makes heavy reading.

G. FREDERICK SMITH

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

The Development of Physiological Chemistry in the United States. American Chemical Society Monograph, No. 54. RUSSELL H. CHITTENDEN, Professor of Physiological Chemistry in the Sheffield Scientific School of Yale University, 1882–1922. The Chemical Catalog Co., Inc., New York City, 1930. xiv + 427 pp. 15 × 23.5 cm. $6.00.

This book is unique. The author has combined the readability of a modern history with a fund of information worthy of an encyclopedia.

The first chapter gives an account of the author's experiences in Kuehne's laboratory at Heidelberg and tells of the beginnings of physiological chemistry in Germany and France and of its importation into this country in 1874.

Subsequent chapters take up the work in the United States from that date on. The plan of development is as near the chronological as can be attained with such a many-branched subject as physiological chemistry. The work of individuals and groups is recorded and to this is added interesting personal facts about the workers, the times and places at which the work was done, the reasons for undertaking the projects, and their effects on physiological chemistry at large.

At no time does the author become involved in deeply specialized chemistry or physiology. To one only casually interested in physiological chemistry the book presents an admirable bird's-eye view of the work done in the United States and enough of that done outside of it to complete the picture. To the biochemist it gives a concise record of men and their work which could be secured only by long digging at the periodical literature.

The developments of the past two years are only partly covered. For instance the current revolution in carbohydrate chemistry and Kamm's work on alpha and beta hypophamines are not mentioned.

G. H. WOOLLETT

UNIVERSITY OF MISSISSIPPI
UNIVERSITY, MISSISSIPPI

Fundamentals of Organic Chemistry. HARRY F. LEWIS, Professor of Organic Chemistry, Institute of Paper Chemistry; formerly Professor of Chemistry, Ohio Wesleyan University. First edition, McGraw-Hill Book Co., Inc., New York, 1930. viii + 390 pp. 28 illustrations. 13.5 × 20.25 cm. $2.75.

The book is designed as a text that will serve as both: (1) a survey course for students in a liberal arts college who are not majoring in chemistry; (2) a first course for students majoring in chemistry.

The basis for the text is "Atomic Linkage Theory." The material is developed with particular reference to the number of atoms in a compound, their nature, the nature of the linkage between these atoms, and the arrangements of the atoms in space. The author keeps constantly before the student the linkage involved in the compounds under consideration. The reviewer is somewhat disappointed, however, after having the atomic linkage stressed as the foundation of the text, to find very little use of the electron theory after the second chapter.

Considerable emphasis has been placed upon recent industrial developments in organic chemistry. This undoubtedly aids in holding the student's attention and interest as well as pointing out some of the economic contributions of chemical research. The illustrations used in this connection have been well chosen.

The book is well equipped with references and review questions and has the added feature of suggestions as to the preparation of curves, data, and the reference materials studied. In this respect the text is excellent and furnishes a good background for the presentation of the subject. It appears, however, that the text is much more suitable as a survey course than as a text for chemistry majors. For the latter type of student it would seem that the text would be more useful if it contained some additional material. Even if briefly stated, one might expect some consideration of subjects such as the Beckmann re-

arrangement, triphenylmethyl, pinacol reduction and rearrangement, the 1–4 or conjugated systems, or Baeyer's strain theory with Thorpe's modification. For the beginning student a somewhat more extended index would be helpful. While mentioned in the text, ketones and oximes, for example, do not appear in the index.

The text is well written and the subject matter included is presented in an entirely understandable manner. It carries a decidedly more technical flavor than the average beginning text in organic chemistry. This should prove interesting to the practical-minded student.

J. SAMUEL GUY
O. R. QUAYLE

EMORY UNIVERSITY
EMORY UNIVERSITY, GEORGIA

Laboratory Manual of General Chemistry. HARRY N. HOLMES, Professor of Chemistry in Oberlin College, Oberlin, Ohio. Third edition. The Macmillan Company, New York City, 1930. x + 163 pp. 34 figs. 14 × 22 cm. $1.60.

This laboratory manual is of the interleaved type. The subject material for experimental work is arranged in accord with the usual standardized method, which long experience has demonstrated as yielding the best results with the average general chemistry student in the United States.

The thirty-two chapters, based probably on thirty-two weeks of class work, include the usual Preliminary Exercises, Physical and Chemical Changes, and chapters on Non-Metallic Elements and Compounds Thereof, Equivalent Weights and Valence, Molecular Weights and Formulas, Acids, Bases and Salts, Neutralization, Atomic Structure, Equilibrium, and Hydrocarbons and Their Derivatives. These topics are followed by the Metallic Elements in appropriate groups, also one chapter on Electrochemistry (two pages) and another on Qualitative Analysis (eight pages). The Appendix comprises seven pages of the common appendix material, Vapor Tension of Water, Solubility of Bases and Salts, Electromotive Series, Laboratory Equipment, and Reagents.

The reviewer questions, on pp. 4–7, the use of analytical balances, weighing beyond the second decimal figure with the finding of the zero point, for first-year general chemistry students, especially from the viewpoint of time and significance.

Where silver foil is available, in the quantity needed, the experiment illustrating the law of constant proportions is well planned. On p. 15, the interesting experiment on the drying of paint is one not commonly found in general chemistry laboratory manuals. The ten pages devoted to oxygen and ozone appear, to the reviewer, to be too long for four or even six hours of laboratory time. Oxygen, however, is especially adapted for much student laboratory experimentation. The five pages devoted to hydrogen, because of the amount of quantitative work, is also a heavy assignment for one or two laboratory periods. The use of gelatin capsules for handing milligram-atomic-weight pieces of sodium in the experiments on valence is commendable although it imposes considerable extra work on the storeroom staff. Several experiments have been taken, with acknowledgment, from the JOURNAL OF CHEMICAL EDUCATION. Some experiments are marked with an asterisk, such as No. 17 on p. 22 (Fluorescein Test for Ozone in Air) and Equivalent Weight of Copper in Terms of Silver on p. 32. These are intended for unusually able students. Some experiments such as No. 44, on p. 41, on Carbon Monoxide, are marked optional. The chapter on determination of Molecular Weights and Formulas is a desirable one in general, although the asterisked experiment on the Molecular Weight of Water seems to the reviewer rather costly in student time, materials, and equipment, for the value the student obtains. It is interesting to note the presence of an asterisked experiment illustrating the Law of DuLong and Petit, a topic of considerable importance but one not frequently found in our leading general

chemistry texts. The chapter on Solutions is worthy of a place in a Laboratory Manual of Physical Chemistry.

Dr. Holmes' efforts to include the latest advancements in the field of chemistry and chemical theories led to the inclusion of a chapter (one and one-half pages) on the preparation of atomic structure models according to the Langmuir-Lewis theory. The use of toothpicks, chewing gum, and wax by students standing at the average chemistry work bench does not seem of sufficient value, to the reviewer, to warrant introduction. Likewise, experiment No. 143 on p. 104 on coal distillation can best be demonstrated to a class. The cleaning of pyrex glass ignition tubes after heating of bituminous coal is not economical to the student, neither is it desirable to include a piece of iron or steel tube in the student's equipment. It is sometimes alleged that Dr. Holmes stresses aluminum, which is quite natural. The chapter on aluminum comprises only about three pages, however. The chapter on colloids contains well-selected experiments as one could expect from the author's general interest and his having written a Laboratory Manual of Colloid Chemistry. Questions are introduced frequently to bring out specific features of an experiment.

That this manual is a good one in a large field of competitors is obvious to all who have had sufficient experience in general chemistry laboratory work. The student who performs the experiments as directed will have dealt with a mass of experimental evidence on substances and the changes they undergo and generalizations pertaining to such changes.

C. A. BRAUTLECHT

UNIVERSITY OF MAINE
ORONO, MAINE

Laboratory Instruction in the Field of Inorganic Chemistry. VICTOR HERBERT NOLL. Educational Specialist, National Survey of Secondary Education. First edition, The University of Minnesota Press, Minneapolis, Minnesota, 1930. xix + 164 pp. 74 tables. 15 × 23 cm. $2.00.

This book, which is the third volume of a series, entitled "The Teaching of Science at the College Level," reports the results of investigations conducted at the University of Minnesota regarding the value of laboratory instruction in inorganic college chemistry courses. The author states that the purposes of this investigation are to answer the following questions: "1. What is the value to the student of individual laboratory work as compared with other methods of instruction, such as oral quizzes, recitations, and outside reading? 2. Do students who spend more time in the laboratory gain significantly more from the course than students of equal ability who do less laboratory work? 3. What technics can be devised in the form of written examinations to measure differences in students who have not had the same amount of laboratory training?"

The principal experiments conducted are the investigation of the value of five hours of individual laboratory work per week as compared with (1) three hours of laboratory work with two hours of outside reading; (2) three hours of laboratory work with one hour of recitation or oral quiz; and (3) three hours of laboratory work. A comprehensive appendix furnishes details regarding the various tests used and the data from which the table and conclusions of the text were developed.

These problems are attacked from an educational viewpoint and are admirably organized and developed in that direction. The author, who maintains a rigid scientific viewpoint, is pleasingly disinclined to adopt spectacular conclusions. He concludes "that two hours of laboratory work out of five do not seem indispensable," that one hour of recitation or oral quiz seems a fairly profitable substitute for these two hours of laboratory work, but that two hours of outside reading do not. These conclusions are accompanied by a caution that the results of the study are not yet suitable for definite generalizations. This view is probably based upon the fact that few of the results obtained are statistically significant. Due to this

fact, general trends of data are used as a basis for conclusions. Except for this limitation the author mainly accomplishes his purpose. Where he fails, he so states.

In this subject, which is of great interest to teachers of college chemistry, Dr. Noll has made definite progress. Although the problems outlined are not yet solved, they should encourage further work. It is unfortunate that the problem could not be considered also from the viewpoint of the chemist, as to actual professional accomplishments. This, of course, is the final test of the value of laboratory requirements in chemistry and a chemist wonders if even the most skilful of written examinations can replace it.

The book might well have included a list of definitions for abbreviations. The frequent occurrence in the text of abbreviations which most teachers of chemistry will not understand limits considerably the value of the book. Although it is a research in education, a style better adapted to chemistry teachers would have resulted in the derivation of the maximum benefit for the teaching of chemistry.

On line 11, page 87, there is apparently a misprint. The expression, "Group III a, which had only three hours of laboratory—" presumably should be "Group III b, which had only three hours of laboratory—."

W. E. BRADT

THE STATE COLLEGE OF WASHINGTON
PULLMAN, WASH.

Experimental Chemistry. FREDERICK COLLINS, F.R.A.S. D. Appleton and Co., New York, 1930. xvii + 276 pp. 108 illustrations. 12.5 × 19 cm. $2.00.

The book is intended to cover a home course in chemistry. A complete series of experiments is included, clearly described, together with a discussion of the cause of their reactions.

The illustrations (by the author) are crudely drawn, but this should not detract from the value of the experiments. Each time an element or compound is mentioned, the symbol or formula is given in parenthesis. This repetition will surely leave an imprint on the mind of the young experimenter as to the significance of formula and when he reaches the end of the book he most certainly will have retained some of them. The use of certain terminology is not to be commended; thus "Old Man Chlorine," "Sweet Mamma Iodine," "Miss Bromine," and "Little Sister Fluorine" are endearing terms which the reviewer feels should not have been included.

The book is easy to read and should go far in helping to popularize chemistry.

E. G. VANDEN BOSCHE

UNIVERSITY OF MARYLAND
BALTIMORE, MARYLAND

Synthetic Inorganic Chemistry. A. A. BLANCHARD, Ph.D., Associate Professor Inorganic Chemistry, and J. W. PHELAN, Professor Inorganic Chemistry, both of Massachusetts Institute of Technology. Fourth edition, John Wiley and Sons, Inc., New York City, 1930. xii + 322 pp. 22 figures. 15 × 23 cm. $3.00.

"Synthetic Inorganic Chemistry" is a combined text and laboratory manual for students who have had a good course in high-school chemistry. It is used in the freshman class at M. I. T. where all the students are required to have passed entrance requirements in chemistry.

The book is designed chiefly from a laboratory standpoint. Each chapter is divided into two parts, the first containing experiments and the second a discussion of the theory involved. An excellent series of problems and questions is found at the end of each unit.

This arrangement of material is such a departure from the usual elementary text, that a student need experience no boredom because of having had a course in the secondary schools.

The first four chapters are devoted to the following topics: (1) Quantitative Aspects, (2) Water and Solution, (3) Theory of Ionization, and (4) Non-Metallic Elements in Binary Compounds. The last six chapters are taken up with the preparation of compounds in the order of the periodic system.

Those familiar with the 1922 edition will find the general plan unchanged. Some of the discussion and questions have been revised and nine new preparations are included which involve work with the less common elements such as cerium, titanium, selenium, molybdenum, and tungsten.

The experiments are clearly written with detailed directions and the theoretical discussions are presented so simply and forcefully that a student should have no difficulty in understanding the work.

Seventy-five preparations as well as many minor experiments are given, hence the individual teacher is permitted quite a wide choice of material. In addition to a table of solubilities the appendix includes an excellent brief discussion on the structure of matter in connection with the periodic system.

Aside from classroom work the directions should prove valuable to many who desire explicit information on these special inorganic preparations.

This book deserves the consideration of those teachers who have been seeking a different text for the more advanced freshman student.

CHARLES E. WHITE
UNIVERSITY OF MARYLAND
COLLEGE PARK, MD.

MISCELLANEOUS PUBLICATIONS

British Chemicals and Their Manufacturers. THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS. London, 1931. 405 pp. 13.5 × 21.4 cm.

This volume includes a directory of members, a classified list of products, a list of proprietary and trade names, and alphabetical indexes in several languages. The volume may be obtained gratis by genuine users of chemicals, but only by direct application to the office of The Association of British Chemical Manufacturers, 166 Piccadilly, London, W. 1.

Official Directory of the British Chemical Plant Manufacturers' Association. London, 1931. 151 pp. 14 × 22 cm.

Contains the roster of officers, an introduction, the directory of members of the Association, a classified list of products and services and members' advertisements. The directory may be obtained gratis by genuine users of chemical plant, but only by direct application to the office of The British Chemical Plant Manufacturers' Association, 166 Piccadilly, London, W. 1.

Publications of the U. S. Office of Education of Special Interest to High-School Teachers. UNITED STATES DEPARTMENT OF THE INTERIOR, Office of Education, Washington, D. C. August, 1930. 7 pp. 15 × 23 cm. Gratis.

The Nature Almanac. A Handbook of Nature Education. THE AMERICAN NATURE ASSOCIATION, Washington, D. C., 1930. vii × 399 pp. $1.00.

New Pump Atomizes Oil to Raise It from Well Bottom. Petroleum is brought from the bottom of deep wells to ground surface by atomizing it with air or gas in a new turbine air-lift pump said to be the invention of Ralph H. Tucker. Crooked wells that curve or spiral their way downward, which are very difficult to pump with sucker rods, can be robbed of their oil as easily as a straight shaft by the new atomizing process.

The air-lift pump is operated by air or gas pressure applied to an enclosed area in the bottom of the tubing. Air enters the pump through angular slots which turn a motor similar to a steam turbine. Oil is picked up by the motor; it strikes the air column at the top of the pump and is completely atomized. At the surface oil and air are separated in tanks.—*Science Service*